EARTHQUAKE HAZARDS AND HOUSING

Volume 1

By Mary Comerio,
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CENTER FOR ENVIRONMENTAL
CHANGE, INC.
For
SAN FRANCISCO
DEPARTMENT OF CITY PLANNING

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EARTHQUAKE HAZARDS AND HOUSING: THE IMPACT OF A RETROACTIVE SEISMIC UPGRADING ORDINANCE ON LOW INCOME HOUSING IN SAN FRANCISCO

Prepared for
San Francisco Department of City Planning

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March 1987

The Center for Environmental Change, Inc. is a non-profit Community Design Center affiliated with the Department of Architecture at the University of California, Berkeley. The Center was established in 1979 and has provided Bay Area communities and non-profit organizations with research, planning and architectural assistance on more than 100 projects. The past work includes the design of new self-help housing, rehabilitation of existing housing, day care centers, health clinics, theaters, parks, churches, and other community facilities. Neighborhood and land use planning studies, advocacy planning and a variety of educational programs and publications on housing rehabilitation and seismic retrofit compliment the Center's architectural services.

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Mary C. Comerio
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EXECUTIVE SUMMARY

Protecting the housing stock in downtown neighborhoods has been a concern in the city of San Francisco for some years. The city has recognized that buildings in neighborhoods like Chinatown, the Tenderloin, and the Bush Street Corridor are a valuable and irreplaceable resource of low-income housing. As a result the city has consistently enacted legislation [1] to keep the buildings from being torn down and to keep the housing units from being converted to other uses.

Unfortunately, most of the buildings in these neighborhoods were built in the period between 1906 and 1925 and they are made of unreinforced brick. Recent experiences in the United States, Japan, China, Italy and Yugoslavia, have made it clear that brick buildings, as part of a category of building types known as unreinforced masonry (URM), are particularly vulnerable during earthquakes. In the same vein, recent advances in structural engineering have led building officials in earthquake-prone areas to consider new building codes that would require owners to retrofit URM buildings to new standards for seismic safety.

While everyone would agree that making buildings safer and protecting the lives of citizens is a worthy under taking, the cost of seismic upgrading could force building owners to demolish marginal buildings, evict tenants during the construction process, and raise rents significantly. As such, it is important to look at the particular circumstances in San Francisco before enacting legislation. There are 769 unreinforced masonry residential buildings with approximately 10,000 apartment units, 10,000 residential hotel units and 5,000 units classified as "tourist" hotel units. Seventy percent of all the URM housing units are located in Chinatown, the Tenderloin, and the Bush Street Corridor, the remaining 30% are located in adjacent downtown neighborhoods. In the Chinatown core, more than 50% of the residential building stock is built of unreinforced masonry. In the Tenderloin the figure is 40%. With so many low-income housing units at risk, we should understand the economic and social costs of a retroactive seismic upgrading ordinance, before enacting one.

This study looks at a range of seismic upgrading measures for prototypical residential buildings in San Francisco and their associated construction costs. It also looks at the financial profile of owners of and tenants in URM buildings in order to assess the impact of a new building code, and to make recommendations for a policy that improves the life safety of the existing residential building stock and at the same time maintains that stock as low-income housing.

On the engineering side of the question, there is a great deal of new knowledge about building failure but very few buildings which have been seismically upgraded have been in an actual earthquake. Therefore, how much bracing is required or what construction methods work best are subjects of some debate in the engineering community. It is generally agreed that bolting the floors and walls together (which prevents the exterior masonry wall from falling outward and away form the wood frame interior) provides a significant margin of safety for a minimal cost. For San Francisco buildings this cost is approximately $6 per square foot or about $1000 per unit.

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[1] Numerous ordinances can be cited from the very specific such as the Residential Hotel Preservation Ordinance in 1979 to the more general reduction of height limits, historic districting, and moratoriums on new construction.

Although some engineers would agree that this is all that need be done to improve the life safety of residential buildings, our consultants and most engineers would not be comfortable with such a cook-book solution. Because the size, shape and height of a building influence how well the building resists lateral force, each building needs to be evaluated individually to determine the minimum amount of strengthening required to make it safe.

For example, 94% of the residential buildings in San Francisco are similar to our study prototype 2. These are rectangular, 3 or 4 story apartment or hotel buildings sometimes with a commercial ground floor. Because the particular building we studied was long and narrow, and there were no interior supports in the commercial space, the building required some shear bracing at the ground floor level in addition to the anchor bolts. The cost for this retrofit was approximately $10 per square foot.

Cities that have adopted retroactive codes have adopted requirements that are more stringent than what we have recommended as a minimum acceptable level of safety. But even these codes recognize that it is impossible to bring old buildings up to the most current building code requirements. Seismic strengthening requirements for existing buildings are generally based on occupancy and use as well as a specific level of lateral force resistance. Different cities have adopted different standards. Santa Rosa uses the 1955 Uniform Building Code (UBC) as a basis for its lateral force requirements. Long Beach originally used the 1976 UBC but later reduced lateral force requirements to the level of the 1970 UBC. Current San Francisco requirements are equivalent to the 1973 UBC, but these apply only when a change of use or a substantial amount of renovation work triggers the seismic upgrading requirement.

For this study we used the lateral force requirements in the Los Angeles ordinance for strengthening levels 1 & 2 and the 1985 UBC for level 3. The costs to seismically upgrade typical San Francisco buildings to levels 1 and 2 range from $16 to $25 per square foot, while level 3 costs are approximately $38 per square foot.

Experience in other cities has shown that when seismic upgrading is required, owners use the requirement as an opportunity to repair other code violations and do cosmetic rehabilitation work. This additional work is often required by financial institutions that want to see improved economic value if the property acquires more debt. If seismic costs range from $4-6000 per unit, owners are typically spending an additional $8,000 per unit for other rehabilitation.

What do these costs mean? For tenants, every $1,000 of upgrading cost translates into a $13.22 per month rent increase under allowable rent pass-throughs in the current San Francisco Rent Stabilization Ordinance. This means that if the total upgrading costs $5,000 per unit, the allowable monthly rent increase is $66 per month; if upgrading costs $10,000 per unit, the rent increase is $132; if upgrading costs $15,000, the rent increase is $198; and so on.

Currently the average rent for a residential hotel unit in Chinatown is $150 per month. In the Tenderloin a residential hotel room is $250-275, and a studio apartment is $300-450. For the Bush Street Corridor, an occupied studio rents for $450-480 while a vacant studio is on the market for $525.[2] Rents are particularly low in Chinatown because people tend to live in one place on average of 10-15 years whereas the turnover rate in the Tenderloin and Bush Street areas is 6 months. The population in each of the three neighborhoods is by all account very low income and predominantly elderly.

More than 75% already pay more than 30% of their income for housing. For this population, anything more than $10 to $30 rent increase would be a severe hardship. Even more frightening would be the inevitable displacement. It is very difficult to do seismic rehabilitation with tenants in place and in San Francisco, with a vacancy rate of less than 1%, low rent replacement housing is simply non-existent.

Another concern for tenants and owners, is the real possibility that a significant number of buildings would be torn down. Economically marginal buildings (buildings whose incomes could not support increased debt) would simply not qualify for rehabilitation loans.

Although we were unable to do a specific breakdown by owner, national statistics suggest that 60% of the owners of downtown residential buildings are "mom & pop's" who depend on their building as a source of income. The majority of buildings in Chinatown have been held by the same owner for at least 15 years. (Only 3 URM buildings have changed ownership in the last 5 years.) Because banks tend to require a higher than normal (often 40%) equity position for Chinatown building owners to obtain financing, because these buildings have been held for a long period, and because ground floor commercial space commands $4-5 per square foot rents, Chinatown buildings tend to have positive cash flows despite low residential rents. But these owners, primarily individuals and family associations, would have the most difficulty in obtaining rehabilitation financing and can least afford to lose income.

In the Tenderloin and Bush Street areas, rents are increasing with more rapid tenant turnovers and there seems to be an healthy market in residential buildings (at least 12 sales of URM buildings per year since 1981) despite the fact that current rents are not covering the building expenses and debt service. One could speculate that people are buying buildings in hopes of raising rents, but it is hard to imagine that owners who are currently operating with negative cash flows would be able to increase their debt for a seismic retrofit.

---

[2] Under the current law landlords are allowed to raise rents more than 4% a year if a unit becomes vacant.

In essence anything but the minimal seismic upgrading would have a significant negative impact on building owners and tenants. That is not to say that a seismic rehabilitation program should not exist, but that a building code alone could cause more housing problems than it solves. Thus we suggest that policy makers recognize that different levels of safety and risk already exist in our buildings as in most aspects of society. We live with the inefficiencies and inadequacies of our older buildings even though we develop more stringent standards for new construction, just as we accept the fact that our school districts cannot buy a new fleet of school buses every year even though it would be "safer" for our children. Thus there is nothing wrong with bringing a 1915 building up to the safety standards of 1964 even though it would be "safer" to bring it up to 1973 or 1985 standards.

The question of how much safety should be mandated is always difficult for policy-makers. It is hard to put a dollar value on the cost of a life increase life-safety in downtown neighborhoods. However, to preserve and maintain the low-income housing stock in China town, the Tenderloin and the Bush Street Corridor, we recommend that as part of a general earthquake hazards reduction ordinance for unreinforced masonry buildings, the city require only the minimum upgrade requirements for all buildings with housing units.[3] The code should be written to require bolting floors and walls as a base for the minimum with some latitude for engineering judgment regarding the need for additional bracing because the building has a "soft" first story or other feature that would require additional strengthening to meet the acceptable minimum. The State Historic Building Code and the Uniform Code for Building Conservation set a precedent for this type of code.

To further protect the low-income housing stock, the ordinance should discourage demolition of existing buildings, and should include specific provisions for a city sponsored and coordinated program for citing and scheduling buildings for renovation. The ordinance must be crafted to work with the city's rent stabilization ordinance to insure adequate relocation assistance and fair rent increases. Of course, the ordinance must not conflict with other city housing and zoning regulations. To be effective in San Francisco, an earthquake hazards reduction ordinance should be more than a building code, it should be a comprehensive program for building and housing conservation.

This implies that the implementation of such an ordinance must be as carefully designed as the ordinance itself, including a city sponsored program to provide financing assistance for economically marginal buildings which house low-income tenants. Finally, the city should carefully manage and phase the implementation of a seismic rehabilitation program, organizing and maintaining a temporary housing relocation site for tenants whose buildings are under construction. To run effectively with cooperation among numerous city departments and agencies this kind of program needs a 20 year timeline.

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[3] A number of cost-benefit studies show that once minimal upgrading requirements are met, a 10% increase in lives saved would require a 100% increase in costs. (See Chapter 4.)

The total cost of a sensitive seismic upgrading program is difficult to compute. Let us assume that to meet minimum seismic rehabilitation standards will cost an average of $23,000 per unit and that rehabilitation costs for the repair of code violations and other cosmetic/architectural work will average 5-8,000 per unit. For 25,000 units the seismic cost is approximately $50-75 million while the total rehabilitation cost ranges from $175-275 million. Of course these are average figures which do not include costs for the provision of temporary housing or program management.

Even so, the costs are not unreasonable or unmanageable. Direct financial assistance for owners might be available through state and federal grant/or loan programs, (e.g., Community Development Block Grants, HUD programs, tax exempt bonds, etc.) Indirect financial assistance may come from a new state seismic tax credit, or federal tax savings created by incentives in the 1986 tax reform for seismic improvements.

The materials in this study provide the background issues for analyzing and implementing policies and programs on earthquake hazards and housing. The limited and preliminary suggestions on how to finance a seismic upgrading program are intended only to point out that it is conceivable and possible to develop a earthquake hazards reduction ordinance and conserve the precious low-income housing stock in San Francisco. Ultimately, the issue is not the price tag for such a program, nor is it how much of that cost should be paid by the city. The real issue for the city is to decide to make seismic safety and housing conservation a policy priority.

CHAPTER I: INTRODUCTION

While it is commonly acknowledged that the San Francisco Bay Region is vulnerable to earthquakes, the magnitude of this threat has perhaps been forgotten by the general public due to the lack of major seismic activity in the past several decades. However, in 1868 movement along the Hayward fault produced an earthquake of magnitude 7 on the Richter Scale and in 1906 the great San Francisco earthquake of Richter magnitude 8.3 resulted from movement along the San Andreas fault. These two faults are part of a system of at least ten known active faults lying beneath the San Francisco Bay Region. (See Figure 1.) These faults, although relatively quiet in recent decades, are all capable of producing earthquakes of 6.0 or greater Richter magnitude.[1] Further, one could reasonably expect not just large, but catastrophic earthquakes in the Bay Area at any time.[2]

The protection of life and property during earthquakes is largely entrusted to the engineering profession. The 1933 Long Beach quake made quite explicit the significant threat to life safety posed by earthquakes, and society demanded new safety regulations and a working technology capable of complying. Thus seismic building codes and construction technology have evolved since 1933. Subsequent earthquake experiences have added to the body of engineering knowledge and new perceptions of associated risks.

Until relatively recently, codes regulating seismic force requirements had focused primarily on new construction. The implied attitude was that existing buildings would soon be replaced and it was not worthwhile to upgrade the existing building stock. However, recent interest in preservation and building conservation have increased the life-span of older buildings. As a result, in the last decade there has been increased concern with seismic regulations specific to the renovation of existing buildings.

Building collapse is the primary threat to life safety in an earthquake, and the buildings most vulnerable to collapse are those made of unreinforced masonry (URM) bearing walls. Buildings of this type were generally built before implementation of the 1933 Uniform Building Code. These buildings were typically not designed for the resistance of lateral loads induced by a major damaging earthquake. The masonry wall does not contain any steel or other types of reinforcement, causing the wall to have a lower shear resistance. Brick buildings are particularly hazardous because there is no continuity in the structure, and the old lime mortar loses bonding capability over time, and often fails during earthquakes. Further, the floors and roof are generally not tied to the walls, and so in an earthquake they tend to push the walls out, inducing collapse.

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[1] Bay Area Earthquake Study, Earthquake Preparedness in the San Francisco Bay Region, September 1984, Pg. 10.

[2] Ibid.

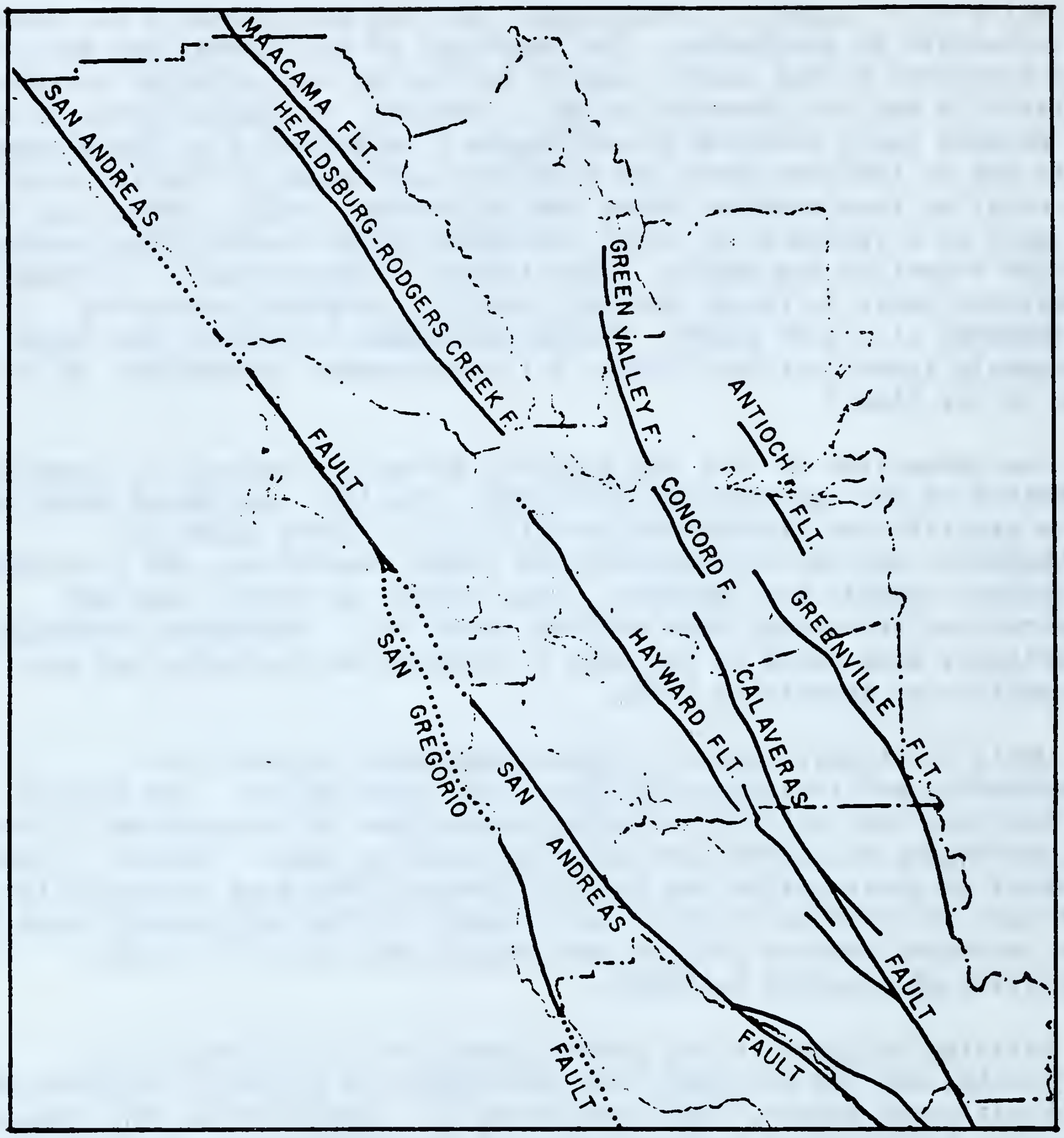


Figure 1
Major Active Faults in the San Francisco Bay Region

Source: Bay Area Earthquake Preparedness in the San Francisco Bay Region, 1984.

Region	Fault System	Richter Magnitude[1]	Current Annual Probability of Occurrence (Percent)	Likelihood of Occurrence in Next 20-30 Years
Los Angeles-San Bernadino	Southern San Andreas	8.3	2-5	High
San Francisco Bay Area	Northern San Andreas	8.3	1	Moderate
San Francisco Bay Area	Hayward	7.4	1	Moderate
Los Angeles	Newport-Inglewood	7.5	0.1	Moderate-Low
San Diego	Rose Canyon	7.0	0.01	Low
Riverside San Bernardino	Cucamonga	6.8	0.1	Moderate-Low
Los Angeles	Santa Monica	6.7	0.01	Low

[1] This is the estimated largest magnitude earthquake expected at a reasonable level of probability. The main shock can be expected to be followed by large aftershocks over a period of weeks or longer. Each large aftershock would be capable of producing additional significant damage and hampering disaster assistance operations.

Figure 2
Probability of Major Earthquake in California

Source: ASSESSMENT OF THE CONSEQUENCES AND PREPARATIONS FOR A CATASTROPHIC CALIFORNIA EARTHQUAKE: FINDING AND ACTIONS TAKEN, Prepared by the Federal Emergency Management Agency from an analysis caried out by the National Security Council Ad Hoc Committee on Assessment of Consequences and Preparations for a Major California Earthquake. Washington, D.C., 1980.

This study recognizes the potential hazards posed by the unreinforced masonry building stock in San Francisco, especially because this building stock is concentrated in downtown neighborhoods. At the same time, we recognize that the neighborhoods with the highest concentrations of unreinforced masonry housing units, Chinatown, the Tenderloin and the Bush Street Corridor are inhabited primarily by low and moderate income people, many of them elderly and on fixed incomes.

Thus, the purpose of this study is to bring together concerns for life safety and housing conservation, in order to develop policy recommendations for improving the buildings with minimal disruption to the community. The study has two major parts. The first is an investigation of seismic strengthening methods, building code requirements, and construction costs. The second part is an investigation of the financial characteristics of residential buildings in Chinatown, the Tenderloin, and the Bush Street Corridor in order to assess the impact of seismic upgrading costs on building owners and tenants.

In the engineering component the methodology was to review all pertinent state and local seismic codes, and compare these to the policies of other jurisdictions in the western region which have enacted seismic safety ordinances. Particular attention was paid to Los Angeles because their 1981 ordinance represents the latest model for cities with large numbers of URM buildings. We also reviewed the "state of the art" engineering designs and construction details in order to understand the levels of life safety associated with various retrofit techniques and code requirements. With this technical information in hand we used the Bureau of Building Inspection's (BBI) Survey of Hazardous Buildings to select a number of prototypical residential buildings for detailed engineering and cost studies.

In the housing component, the methodology was to use the BBI Survey of Hazardous buildings to identify concentrations of unreinforced masonry residential stock, and then to collect demographic and financial data on these areas. Because census data is nearly 8 years old, we conducted extensive interviews with banks, building owners, property managers, tenants, family associations, community organizations and city agencies to collect current information on rents, operating expenses, and general financial conditions by neighborhood. We created a number of financial prototypes from these detailed case studies so that typical building renovation costs could be evaluated against typical economic conditions.

As we will demonstrate, compliance with current codes and standards is very expensive. To enact a retroactive seismic upgrading ordinance in San Francisco based on the Los Angeles model would put a significant number of inner-city housing units at risk. These could be described in three problem areas: Loss of housing units through demolition, displacement of tenants through required relocations and rental increases, and lack of available funding to subsidize upgrading costs and/or rents.

Applicable to California Buildings Constructed Priot to 1933.*
See Text and References Cited in the Bibliography for Limitations

Simplified Description of Building Construction Class	Deaths/10,000 Occupants
Small wood frame, such as the average older home	4
Large wood frame, such as large older apartment buildings	10
Small all-metal buildings, such as gasoline stations	4
Large all-metal buildings, such as large factories	15
Steel frame, such as older as older multistory buildings	10-50
Steel frame, such as auditoriums and similar large open areas	50-1500
Reinforced concrete, such as older multistory buildings	100-500
Reinforced Concrete, such as auditoriums and similar large open areas	200-2500
Mixed construction, such as concrete walls, wood roof and floors	800-2000
Mixed construction, such as unreinforced brick walls, wood roof and floors	4000

*Modern reinforced earthquake resistive brickwork was an unknown product before the 1933 Long Beach earthquake.

Note: Table condensed from Steinbrugge and others, 1979.

Figure 3
Maximum Probable Deaths Per 10,000 Occupants

Source: Steinbrugge, Karl V. and Henry J. Lagorio, "Relative Earthquake Safety in Buildings," California Geology, June 1985.

Economically marginal building owners would be unable to obtain public or private financing for seismic improvements and these buildings would be demolished and lost as a housing resource. Where building renovation would be possible financially, the nature of the construction work would require the building to be empty. The relocation problems for tenants in downtown neighborhoods is staggering. Finally, the prospects for federal and state financing assistance are negligible. With current resources, the city would only be able to help a small portion of the building owners with low cost financing. This means that the greatest portion of the seismic upgrading costs would be passed through to tenants as rent increases. In some areas it is doubtful whether or not the market could bear significant (50 to 100%) rent increases. Clearly, such increases would be exceedingly difficult for the current inhabitants to absorb.

Fortunately, our research has shown that the policy choices are not black and white. By choosing realistic standards for building rehabilitation and designing a careful implementation program, the city can achieve substantial improvements in life safety without undue cost disruption or displacement.

CHAPTER II: UNREINFORCED MASONRY HOUSING

CONDITIONS IN SAN FRANCISCO

INTRODUCTION

Of San Francisco's 208,000 housing units 20,349, or /9.8%, are located in unreinforced masonry or seismically hazardous buildings. Most of these buildings are located in the areas known as Chinatown and the Tenderloin where 51% and 43%, respectively, of the housing units are located in unreinforced masonry buildings. These units are inhabited primarily by low and moderate-income people, many of them elderly and on fixed incomes. Large numbers of these units are considered substandard, that is, they are overcrowded and do not have private bathrooms. If the residents of these units are dislocated by eviction, rent increases, or building demolition, it is likely that many will be unable to find replacement housing. Many will be unable to afford a higher rent and will be unlikely to find housing at the same or lower rent levels than they are currently paying since they are already in the lowest cost housing in the city.

In this chapter we will explain where most of the unreinforced masonry residential units are located, describe the quality of the housing in these units, and identify some financial characteristics of the people who live in them. Later in the Chapter we will examine the cash flow of these seismically hazardous residential buildings and the financial decisions that building owners will face if various seismic upgrading ordinances are adopted. Among other options, owners may be able to use a seismic upgrading ordinance to evict tenants and demolish the building, or upgrade the building into a different rental market, or an owner may be able to justify a substantial rent increase due to the cost of upgrading. If any of these options are chosen, the current residents of these buildings, who are disproportionately poor and on fixed incomes, may join the ranks of San Francisco's street people. Policy makers will need to carefully evaluate potential reactions to a given upgrading ordinance and the eventual effect on building tenants. They must determine if the decreased risk of death and injury from a future earthquake is worth the probability of immediately increasing the number of homeless, or if an ordinance can be crafted that will increase safety without displacing residents.

There are approximately 130,000 buildings in San Francisco. Of these, the Bureau of Building Inspection has identified 2058, or 1.6%, that are constructed of unreinforced masonry and therefore considered seismically hazardous. Of the 19,600 residential buildings in San Francisco, the Bureau of Building Inspection found 769, or 3.9% that are seismically hazardous due to construction materials. These 769 buildings contain approximately 20,349 residential units which is 9.8% of the city's housing stock. (See Table 1.) In addition, these buildings contain an additional 5138 "tourist" hotel units, many of which are probably used on a residential basis.

The majority of these unreinforced masonry residential units are among the lowest quality housing in the city. Half, 50.5%, are residential hotel units, many without private plumbing and overcrowded. As we will show below, over 70% of these units are located in areas of the city known as Chinatown, the Tenderloin, and what we call the Bush Street Corridor, areas where much of the housing is substandard and many of the residents have very low incomes.

	San Francisco Total	URMs in San Francisco	Percent of Bldgs that are URM (a)
Buildings	130,000	2058	1.6%
Residential Building	19,600	769	3.9%
Residential Hotel Buildings	556	249	44.8%
Apartment Buildings	18,722	376	2.0%
Other Residential (a) (b)	322	144	44.7%

Table 1 A
Unreinforced Masonry Buildings in San Francisco
As a Percentage of Building Stock

(a) Calculated from BBI data
(b) Other residential includes condos, flats, co-ops and dwelling units.

	San Francisco Total	URMs in San Francisco	Percent of Bldgs that are URM (a)
Residential Units	280,000	20,349	9.8%
Apartment Units	156,829	10,069	6.4%
Residential Hotel Units	19,085	10,280	53.9%
Tourist Hotel Units	28,313	5,138	18.1%

Table 1 B
Residential Units in Unreinforced Masonry Buildings in San Francisco

(a) Calculated from BBI data
(b) Other residential includes condos, flats, co-ops and dwelling units.

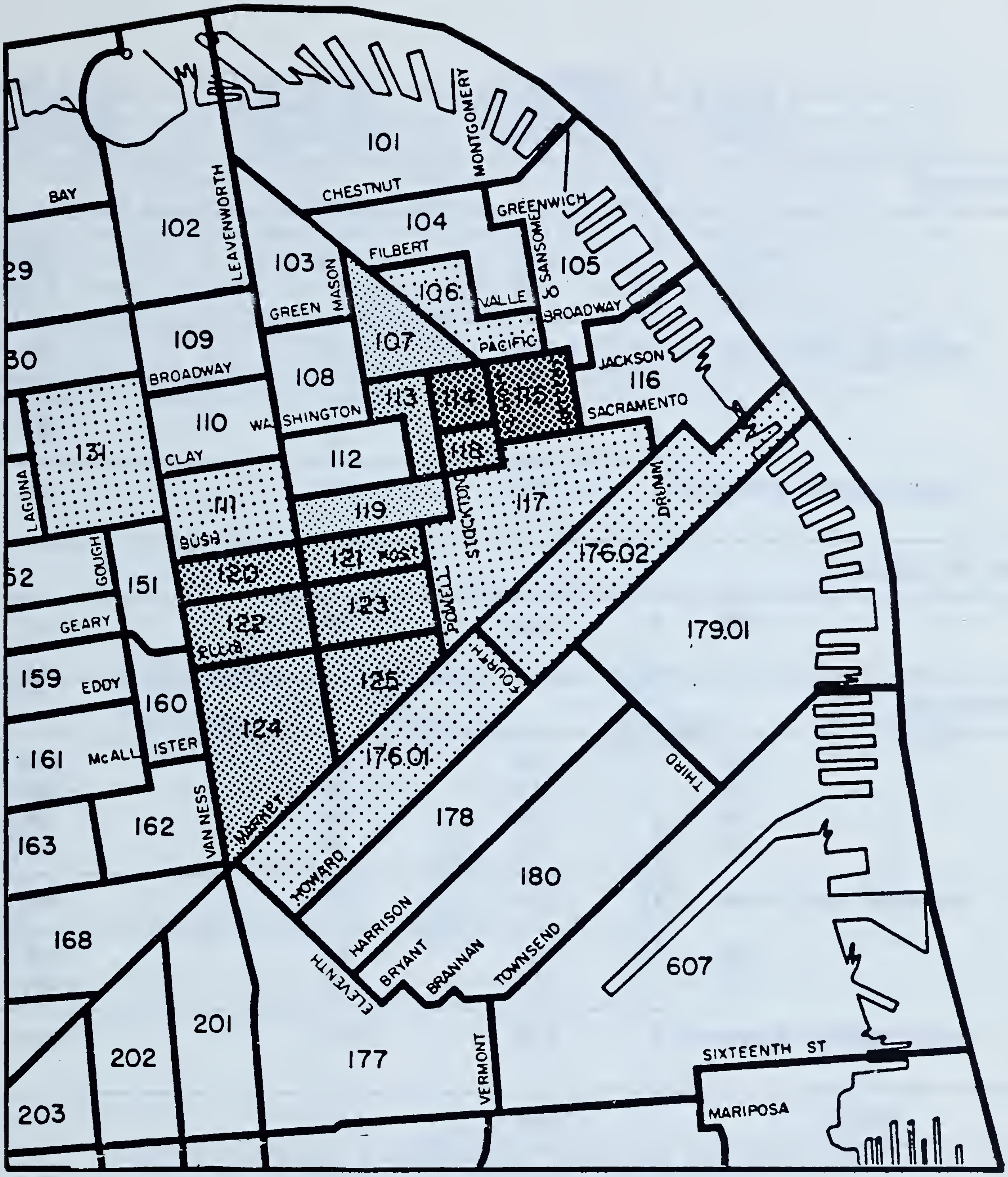
Source: San Francisco Department of Public Works, Bureau of Building Inspection (BBI) Survey of Hazardous Buildings, 1986, and Property Conservation Division Apartment and Hotel Statistics, 1986.

Residential URM buildings in SF	Number of bldgs.	Percent of URM Res. Bldgs
Apartment Buildings	376	49%
Hotels	249	32%
Flats	76	10%
Single-family dwellings	55	7%
Condos & Other	13	2%
Total URM Residential Bldgs.	769	100%

Table 1 C
Residential URM Buildings in San Francisco

Selection of Census Tracts

In order to determine the demographic characteristics of the residents of these buildings, we identified the census tracts with a high proportion of unreinforced masonry buildings. (See Figure 1 and Table 2.) To facilitate our later discussion of the financial conditions of these buildings, we have grouped these tracts into neighborhoods because we have found that we can generalize about such characteristics as debt service and rental income according to the area of the city in which the buildings are located. Five of the census tracts we will be describing (107, 113, 114, 115, 118) are generally included in the Chinatown area, one (119) we call the Bush Street Corridor, and six (120, 121, 122, 123, 124, 125) are included in the Tenderloin or North of Market Street area. The areas encompassed by these census tracts do not completely coincide with "neighborhood" boundaries. However, as they do represent a close approximation, we have grouped them together in order to facilitate a comparative analysis of population and building finance characteristics.



Percent of Residential Bldgs. that are URM:

░ 0 - 25 ▒ 26 - 50 ▓ 51 - 75 █ 76 - 100 ⁞ Adjacent Tracts With Significant URM Residential Bldgs.

Figure 4
Density of URM Residential Buildings
by Census Tract

Census Tract	Number of Residential Buildings	Number of URM Residential Buildings	% of Res. that are URM Buildings (a)
CHINATOWN			
113	123	35	28%
114	71	59	83%
118	48	36	75%
subtotal core area	**242**	**130**	**54%**
107	195	21	10%
115	15	13	87%
neighborhood subtotal	**452**	**164**	**36%**
BUSH ST CORRIDOR			
119	**164**	27	**16%**
TENDERLOIN			
122	135	61	45%
123	114	36	32%
124	107	43	40%
125	83	35	42%
subtotal core area	**439**	**175**	**40%**
120	97	58	60%
121	110	48	44%
neighborhood subtotal	**646**	**281**	**43%**
TOTAL	1262	472	37%

(a) Calculated from BBI data

Table 2
Percentage of URM Residential Buildings
in Select Study Area

Source: San Francisco Department of Public Works, Bureau of Building Inspection (BBI) Survey of Hazards Buildings, 1986, and Property Conservation Division Apartment and Hotel Statistics, 1986.

Other census tracts in San Francisco that have over 100 residential units in more than five unreinforced masonry buildings are shown in Table 3. All except 131 adjoin the tracts listed in Table 2. Although these five census tracts also have a relatively high number or proportion of unreinforced masonry residential units, we did not use them in our analysis because the demographic characteristics of these tracts are too varied to enable us to draw conclusions from an average number. For example tract 117 includes a portion of the area known as Chinatown as well as a large portion of the financial district. The average income of the residents of this tract does not render a meaningful description of people living in URM buildings because there are a significant number of upper income households in modern residential units included in the average.

Census Tract	Number of URM Residential Buildings	Number of URM Residential Units	Number of URM Apartment Units	Number of URM Residential Hotel Units
106	11	173	53	120
111	12	248	174	74
117	20	874	277	597
131	19	379	379	0
176	23	1339	151	1188

Table 3
Unreinforced Masonry Residential Buildings and Units in Census Tracts Adjacent to Select Study Area

Source: San Francisco Department of Public Works, Bureau of Building Inspection (BBI) Survey of Hazardous Buildings, 1986, and Property Conservation Division Apartment and Hotel Statistics, 1986.

NEIGHBORHOOD BUILDING CONDITIONS

In Chinatown 3660 units, or 51% of the housing stock are in unreinforced masonry buildings. (See Table 4.) In the three census tracts that make up the core area of this neighborhood this figure rises to 58%. Note that 2718 units, or 38% of the housing units in Chinatown are residential hotel units in unreinforced masonry buildings. In the Tenderloin area, 43% of the housing units are in unreinforced masonry buildings, and 20% are residential hotel units in unreinforced masonry buildings. The Bush Street Corridor has 4074 residential units of which 22% are in unreinforced masonry buildings.

It is extremely doubtful that residents displaced from these units could find housing at comparable rent levels as rents in these areas are well below the average for most of the city. Our study team gathered rental and other financial data for residential buildings in the study areas as explained in detail in Appendix 2. Table 5 summarizes the rental data we gathered. Occupied unit rents tend to be lower due to the city rent control ordinance that often stabilizes rents at a lower than market rate. These rents reflect what current residents are paying. Advertised rent for vacant units reflects market prices in these areas. While these prices are higher than occupied unit rents, they are still well below rent levels in most other areas of the city.

Census Tract	Number of Res'dntl Units	Number of Res'dntl Units in URM Buildings	Number of Apt. Units in URM Buildings	Number of Res'dntl Hotel Units in URM Buildings	% of Res'dntl Units in URM Buildings
CHINATOWN					
113	1,351	473	241	232	35%
114	1,821	1,265	312	953	69%
118	747	543	246	297	73%
Subtotal core area	**3,919**	**2,281**	**799**	**1,482**	**58%**
107	2,578	793	48	745	31%
115	698	586	32	554	84%
Neighborhood Subtotal	**7,195**	**3,660**	**879**	**2,718**	**51%**
BUSH STREET CORRIDOR					
119	**4,074**	**902**	**770**	**132**	**22%**
TENDERLOIN					
122	3,827	1,707	1,185	522	45%
123	4,385	1,804	597	1,217	41%
124	4,197	1,426	618	808	34%
125	6,060	1,817	558	1,259	45%
Subtotal core area	**16,469**	**6,754**	**2,958**	**3,796**	**41%**
120	3,010	1,441	1,019	422	48%
121	3,076	1,425	1,199	226	46%
Neighborhood subtotal	**22,555**	**9,620**	**5,176**	**4,444**	**43%**
TOTAL	33,824	14,182	6,825	7,294	42%

(a) Calculated from BBI data

Table 4
Number and Percentage of Residential Units in
Unreinforced Masonry Buildings in
Select Study Area Census Tracts

Source: San Francisco Department of Public Works, Bureau of Building Inspection (BBI) Survey of Hazardous Buildings, 1986, and Property Conservation Division Apartment and Hotel Statistics, 1986.

Average Rent in Dollars Per Month

	CHINATOWN	BUSH ST. CORRIDOR	TENDERLOIN
OCCUPIED			
Studio Apartment	$235	$400-500	$300-450
1-Bedroom Apartment	265	450-650	430-530
Residential Hotel Unit	150	N.A.	250-275
VACANT			
Studio Apartment	$450	$450-525	$425-525
1-Bedroom Apartment	550	625	500-675
Residential Hotel Unit	200-225	N.A.	300-330(a) 380-420(b)

(a) without bath
(b) with bath

Table 5
Average Rents for Occupied and Vacant Residential Units
in Select Study Area: 1986

Source: Data collected by study team. See Appendix 1, Section3

SOCIAL CONDITIONS

Using 1980 census data, we found that in the study census tracts residents are disproportionately poor, many are on fixed incomes, and they tend to pay a substantial portion of their income for substandard housing. Twenty to thirty percent of the households in the census tracts with a high proportion of unreinforced masonry buildings, are headed by people 65 or older and therefore presumably on fixed incomes. In some of the Chinatown tracts, the number of households headed by older people is as much as 40 and 45 percent of the total number of households in the tract. (See Table 6.) In addition, unemployment in these tracts is higher than in the rest of the San Francisco SMSA, income is lower, and the number of households on social security or other public assistance is higher. While 7.3 percent of families in the SMSA earn incomes that place them below the poverty level, all but one of the Chinatown census tracts report 10 percent of families below the poverty level with one tract reporting 20 percent. In the Tenderloin tracts, the number of families below the poverty level ranges from 18 to 48 percent of the total (see Table 7.)

Between 44 and 80 percent of the households in these tracts earned less than $10,000 in 1979. Of these, between 44 and 83 percent paid over thirty percent of their income for rent (See Table 8.) Much of the housing that these people rented appears to be substandard. Compared to 1.8 percent for the SMSA, with two exceptions, 11 to 30 percent of the housing units in these tracts do not have a private bathroom. Further, many of the units are very overcrowded. Seven to thirty-six percent house more than one person per room. Only 4.8 percent of the housing units in the whole SMSA are this crowded (See Table 9.)

Table 10 shows the range of the figures that are described above and listed in Tables 6 through 9, for each of our three study neighborhood areas and for the San Francisco SMSA. Chinatown, with 51% of its residential units in unreinforced masonry buildings, appears to have more people on fixed incomes and more substandard housing than the other areas, although all three have a higher number of older people and more substandard housing than the SMSA as a whole. While all tracts have a high unemployment rate and low median income compared to the SMSA, the Tenderloin area, with 43% of its residential units in unreinforced masonry buildings, is particularly high in unemployed and low-income people. All three neighborhoods have a far higher percentage of people living below the poverty level than does the whole SMSA. With approximately half the people in each areas earning less than $10,000 a year, well over half are paying over 30% of their income for housing. Compared to the SMSA as a whole, Chinatown has a very large number of housing units which are considered substandard as they lack private plumbing and are overcrowded. Substandard housing conditions are almost as prevalent in the Tenderloin. Compared to the other two areas, the Bush Street Corridor, with 22% of its housing units in unreinforced masonry buildings, appears to have very little substandard housing, although compared to the SMSA, the amount is high.

It is doubtful that the people who live in these areas, and who are already paying more, as a percentage of income, for less, could find cheaper or replacement housing if these units were to become unavailable, or that they could afford to pay more rent if the units became more expensive. Policy makers should weigh the tradeoffs between safer housing versus no housing for those who will be forced to live on the streets, and should consider that those who might be able to afford a rent increase may prefer a unit with a private bathroom or extra living space over one which is seismically safer.

	CENSUS TRACTS											
		CHINATOWN					BUSH STREET CORRIDOR	TENDERLOIN				
	San Francisco city	Tract 0107	Tract 0113	Tract 0114	Tract 0115	Tract 0118	Tract 0119	Tract 0120	Tract 0121	Tract 0122	Tract 0123	Tract 0124	Tract 0125
TOTAL PERSONS...........................	678,974	5,349	2,840	3,084	842	1,515	4,971	3,154	3,491	5,095	5,070	5,243	4,962
Persons 65 Years and Over.............	104,285	1,518	617	1,030	275	419	790	737	703	1,372	1,383	1,105	959
Percent Persons 65 and Over(a)........	15.4	28.4	21.7	33.4	32.7	27.7	15.9	20.7	20.1	26.9	27.3	21.1	19.3
TOTAL HOUSEHOLDS......................	298,956	1,871	1,117	748	93	590	3,330	2,301	2,522	3,795	3,566	3,691	2,335
Housholder 65 or Older................	67,322	764	388	337	39	205	633	621	570	226	1,110	948	534
Percent Householders 65 or Older(a)...	22.5	40.8	34.7	45.1	41.9	34.7	19.0	27.1	22.6	32.3	31.1	25.7	22.9

(a) Calculated from census figures.

Table 8
Persons and Households with Member 65 and Older in San Francisco and
Study Area Census Tracts: 1980

Source: U.S. Department of Commerce, Bureau of Census, 1979; Census of Population and Housing; Table P1, General Characteristics.

CENSUS TRACTS

		CHINATOWN					BUSH STREET CORRIDOR	TENDERLOIN					
	San Francisco SMSA	Tract 0107	Tract 0113	Tract 0114	Tract 0115	Tract 0118	Tract 0119	Tract 0120	Tract 0121	Tract 0122	Tract 0123	Tract 0124	Tract 0125
CIVILIAN LABOR FORCE................	688,103	2,364	1,460	1,170	388	877	3,321	2,004	2,313	2,417	2,188	2,623	1,778
Unemployed........................	85,211	168	88	77	41	17	218	191	277	236	350	287	301
Percent of civilian labor force unemployed..........	5.8	7.0	8.1	8.8	11.2	2.5	6.6	8.5	8.8	8.8	11.4	10.8	16.8
NUMBER OF HOUSEHOLDS..................	1,283,689	1,854	1,118	743	107	556	3,339	2,268	2,526	3,838	3,607	3,738	2,332
Median income......................	$20,017	$8,800	$12,588	$8,071	$8,125	$11,687	$11,675	$7,510	$10,751	$7,295	$6,250	$6,981	$4,576
RENTER-OCCUPIED HOUSEHOLDS..........,	595,638	1,173	873	680	102	543	3,007	2,259	2,435	3,731	3,583	3,699	2,2317
Median income......................	$13,478	$7,720	$11,373	$7,383	—	$11,477	$11,143	$7,478	$10,525	$7,139	$6,235	$6,837	—
NUMBER OF HOUSEHOLDS WITH EARNINGS...	1,054,310	1,118	809	428	75	395	2,640	1,431	1,966	2,211	2,000	2,235	1,062
Percent of households with earnings(a)................	82.2	80.3	72.4	57.3	70.1	71.1	79.5	63.1	77.8	57.6	55.4	58.8	45.5
Mean earnings......................	$24,123	$14,870	$18,036	$14,237	$18,699	$14,778	$14,508	$10,354	$12,104	$10,812	$9,546	$10,624	$10,712
NUMBER OF HOUSEHOULDS WITH SOCIAL SECURITY INCOME.............	277,488	894	388	335	18	171	622	882	514	1,379	1,214	1,053	688
Percent of households with social security income(a)........	21.8	37.4	34.5	45.1	17.0	30.8	18.7	30.1	20.3	35.9	33.7	28.2	29.4
Mean social security income........	$4,235	$3,804	$3,885	$3,818	$4,152	$3,424	$3,690	$3,345	$3,977	$3,362	$3,716	$3,524	$3,045
NUMBER OF HOUSEHOLDS WITH PUBLIC ASSISTANCE INCOME...........	113,842	474	178	204	38	103	182	234	156	681	820	824	781
Percentage of households with public assistance income(a)......	8.8	25.8	15.7	27.5	28.2	18.5	5.5	10.3	8.2	18.0	22.7	22.1	33.5
Mean public assistance income......	$3,068	$2,535	$2,542	$2,343	$2,348	$2.905	$3,544	$3,068	$3,090	$2,514	$2,561	$2,981	$3,477
TOTAL FAMILIES.......................	806,820	887	584	492	70	282	637	357	373	582	512	527	395
Families below poverty level.......	59,183	101	81	101	5	32	118	142	67	141	184	120	190
Percentage of families below poverty level..............	7.3	10.3	13.8	20.5	7.1	11.3	18.5	38.8	18.0	24.4	37.9	22.8	48.1
PERSONS FOR WHOM POVERTY STATUS IS DETERMINED...............	312,255	882	521	891	178	330	938	1,146	703	1,189	1,516	1,378	1,794
Percentage below poverty level.....	8.8	18.5	18.4	32.4	21.8	20.3	18.8	32.5	20.2	23.8	29.9	26.7	37.2

(a) calculated from census figures

Table 7
Labor Force, Income, Public Assistance and Poverty Characteristics of
Persons, Households, and Families in San Francisco
SMSA and Study Area Census Tracts: 1980

Source: U.S. Department of Commerce, Bureau of Census, 1978; Census of Population and Housing; Table P-10 Labor Force and Disability Characteristics of Persons: 1980. Table P-11 Income and Poverty Status in 1979: 1980

		CENSUS TRACTS										
		CHINATOWN					BUSH STREET CORRIDOR	TENDERLOIN					
	San Fran-cisco SMSA	Tract 0107	Tract 0113	Tract 0114	Tract 0115	Tract 0118	Tract 0118	Tract 0120	Tract 0121	Tract 0122	Tract 0123	Tract 0124	Tract 0125
SPECIFIED RENTER-OCCUPIED HOUSING UNITS......................	592,448	1,888	882	886	88	582	3,018	2,278	2,430	3,678	3,546	3,874	2,328
Renter Households with Income Less than $10,00 in 1979.........	271,882	1,106	438	365	54	273	1,328	1,421	1,158	2,301	2,561	2,452	1,856
Percent of renter households with income of less than $10,000 in 1979(a).............	38.7	80.2	45.3	53.2	56.3	46.8	44.0	62.4	47.7	62.6	72.2	66.7	78.8
Renter Households with Income of Less than $10,00 Who Pay Over 30% of Income for Rent(a)........	183,874	448	255	230	30	218	1,004	1,111	865	1,752	1,717	1,700	1,294
Percent of renter households with income of less than $10,000 who pay over 30% of income for rent(a).........	75.3	44.1	58.5	83.0	55.8	78.9	75.5	78.2	74.7	78.1	67.0	69.3	69.7

(a) Calculated from census figures

Table 8
Low Income Renter Households Paying High Proportion of Income
for Rent in San Francisco SMSA and Study Area Census Tracts: 1980

Source: U.S. Department of Commerce; Bureau of Census; 1980 Census of Population and Housing; Census Tracts, California. Table H-8. Financial Characteristics of Housing Units: 1980

CENSUS TRACTS

		CHINATOWN					BUSH STREET CORRIDOR	TENDERLOIN					
	San Francisco SMSA	Tract 0107	Tract 0113	Tract 0114	Tract 0115	Tract 0118	Tract 0116	Tract 0120	Tract 0121	Tract 0122	Tract 0123	Tract 0124	Tract 0125
TOTAL HOUSING UNITS	1,339,015	1,918	1,178	800	98	632	3,734	2,436	2,875	4,121	4,148	4,107	2,937
Housing Units Lacking Plumbing for Exclusive Use................	23,787	504	138	108	33	144	125	272	75	481	1,049	550	778
Percent Housing Units Lacking Plumbing for Exclusive Use(a)....	1.8	26.3	11.7	13.5	33.7	23.1	3.3	11.2	2.6	11.7	25.3	13.4	26.5
OCCUPIED HOUSING UNITS IN 1979.......	1,280,508	1,871	1,117	746	93	590	3,330	2,301	2,522	3,765	3,566	3,691	2,335
Occupied Housing Units in 1979 with more than 1 Person per room(a)......................	62,003	412	245	206	33	150	216	248	176	314	422	394	375
Percent Occupied Housing Units in 1979 with more than 1 Person per room(a)...............	4.8	22.0	21.9	27.6	35.5	25.4	6.5	10.8	7.0	8.3	11.8	10.7	16.1

(a) Calculated from census figures

Table 9
Number of Percent of Substandard Housing Units in San Francisco SMSA and
Study Area Census Tracts: 1980

Source: U.S. Census Table H-1 Occupancy, Utilization, and Financial Characteristics of Housing Units: 1980. Table H-8. Financial Characteristics of Housing Units: 1980

	CHINATOWN (census tracts 107,113,114,115,118)	BUSH STREET (census tract 119)	TENDERLOIN (census tracts 120-125)	SF SMSA
Percent of People 65 years and over	27.7 - 33.4	15.9	19.3 - 27.3	15.4
Percent of households 65 or older	34.7 - 45.1	19.0	22.6 - 32.3	22.5
Percent of civilian labor unemployed	(2.5) 9.1 - 11.2 (a)	6.6	9.5 - 16.0	5.8
Median household income	$8,071 - $12,596	$11,975	$4,579 - $10,751	$20,017
Median renter—occupied household income	$7,393 - $11,477	$11,143	$6,235 - $10,525	$13,497
Percent of households with public assistance income	15.7 - 27.5	5.5	6.2 - 33.5	9.9
Percent of families below poverty level	7.1 - 20.5	18.5	18.0 - 48.1	7.3
Percent of persons below poverty level	19.4 - 32.4	19.8	20.2 - 37.2	9.9
Percent of rental households with income less than $10,000 in 1979	45.3 - 60.2	44.0	47.7 - 79.6	39.7
Percent of rental households with income less than $10,000 in 1979 who pay over 30% of income for rent	44.1 - 79.9	75.5	67.0 - 79.2	75.3
Percent of housing units lacking plumbing for exclusive use	11.7 - 33.7	3.3	(2.9) 11.2 - 29.5 (a)	1.9
Percent of occupied housing units in 1979 with more than one person per room	21.9 - 35.5	6.5	7.0 - 16.1	4.9

(a) Figures in parenthesis indicate percentages for census tracts that are substantially below the range for other tracts in the neighborhood.

Table 10
Summary of Data by Neighborhood Area

Source: See Tables 8-9.

FINANCIAL CASE STUDIES OF RESIDENTIAL URM BUILDINGS

INTRODUCTION

As the data in the previous section demonstrate, the URM housing stock in San Francisco is a critical housing resource, particularly for low-income and fixed income tenants. The critical negative consequences of a seismic upgrading ordinance are: increased rents as costs are passed through to tenants, extreme upgrading or "gentrification" of buildings, displacement due to demolition, and/or lowered operating and profit margins for owners.

In order to evaluate the potential effects of a retrofit ordinance on this crucial housing stock one must understand the economic circumstances of the affected buildings. Because this financial information is of a confidential nature, our research design faced limitations. A comprehensive building by building survey would have been extremely expensive, and would have encountered significant resistance by owners to revealing personal financial information. A research design based on random sampling, was rejected for this reason as well. In addition, since there is wide variation in such building characteristics as rental history, neighborhood, ownership form, and debt service, it would have been necessary to select an extremely large total sample in order to achieve statistical significance for each subgroup of buildings. Nor was it possible to simply select and analyze a single representative building of each major physical type. Although the buildings in our study can usefully be categorized into a few physical types, their financial circumstances are significantly more diverse. Field research consistently reveals that so far as real estate finance is concerned, "every building is different."

For these reasons we chose to develop prototypes representing typical URM residential structures. The economic prototypes are similar to those analyzed in the engineering portion of this study. However, the economic prototypes do not exist as actual individual buildings. Their financial pro formas are carefully blended hypotheticals, constructed from data collected on nearly 100 buildings owned by private individuals, management companies, family associations, and nonprofit corporations.

To build the financial prototypes, the study team first reviewed the physical characteristics and known ownership patterns of URM residential structures in the study neighborhoods. Based upon this review we selected seven categories representing the most common URM structures. Although the majority of buildings are privately owned, we have included two examples of nonprofit-owned buildings since their income and expense characteristics differ substantially from buildings under private ownership.

We developed financial pro formas for these prototypical buildings using data obtained from a variety of sources. These included: income and expense statements for specific buildings that owners and property managers provided, petitions filed with the San Francisco Residential Rent Stabilization Board, detailed sales listings provided by real estate brokers, and information published in the San Francisco Board of

Realtors' Multiple Listings Service. In addition, we used information from City Assessor's records and data analyzed in City Planning Department documents and in studies conducted by neighborhood organizations.

We supplemented this data by interviewing building owners, property managers, real estate brokers, lenders, community leaders, housing officials, and others who are familiar with the ownership and operating characteristics of residential buildings in the study neighborhoods. Using a variety of information sources, our intention was to neutralize any bias that may have influenced the pro formas had we restricted our analysis to more limited data. We believe that the prototypes realistically represent the financial circumstances of URM residential buildings in San Francisco, particularly in the focused study areas.

STRUCTURE OF THE FINANCIAL PROTOTYPES

The seven prototypes are described in the following pages. Each is represented by a pro forma, an accounting of the revenues, expenses, and investment characteristics of the building. The basic elements of each pro forma are:

1. Revenues are calculated based on the number and type of rental units, the neighborhood, and the amount of commercial space. Although the commercial income figures are based on current market rates, residential rents represent average rents for occupied units and therefore reflect turnover rates typical for each neighborhood.
2. From each building's total potential income we subtract a vacancy/collection loss factor in order to produce a figure representing effective gross (or actual) income (EGI).
3. Operating expenses, including maintenance, utilities, taxes, insurance, and management, are then subtracted to yield the net operating income (NOI). Because property taxes increase substantially when buildings are reassessed upon sale, our operating expense figures differ for each purchase scenario.
4. Debt service typically constitutes a large fraction of total costs, dramatically affects building profitability, and will affect the owner's ability to absorb the expense of seismic upgrading. Unlike rental income and operating expenses, debt service is more a function of the building's history than of current market factors. The current annual debt service will depend upon the building value, the percentage that is financed, and the loan terms. In order to provide financial pictures that reflect a variety of scenarios ranging from long term ownership to recent acquisition, we have calculated the annual debt service that would be currently payable if the building were last financed in 1971, 1976, 1981, and 1986. Using interest rates, loan terms, and sale prices for comparable buildings in the study neighborhoods in those years, we calculate a range of values that reflects the possible debt service load on these buildings today. To simplify our analysis we assume that the buildings have not been refinanced. However, it is likely that a number of buildings owned for a long time have been refinanced. In that case, the current debt service will be higher than that shown in

the prototypes. The method we used to develop our sales price and mortgage assumptions is explained in Appendix 2.

5. We subtract the debt service values from the net operating income to produce the building's before tax cash flow (BTCF) for each financing option.

6. To develop after tax cash flow figures, we first calculate the taxable income that each prototype generates by subtracting interest and depreciation from the NOI. We calculate the 1986 deductions using the mortgage terms and depreciation methods that were in effect during the four hypothetical purchase years. Because the 1981 mortgages are adjustable rate loans, we use current interest rates to calculate the interest deduction for the 1981 purchase scenarios. When allowable, we have used accelerated depreciation, switching to straight-line when appropriate to maximize the deduction.

7. Finally, we show the investor's after tax cash flow (ATCF) using three tax rates to reflect a range of owner income levels. In order to simplify the analysis we make several assumptions. First, we have not examined the tax consequences of building sales, nor have we calculated multi-year return on investment measures. Rather, we restrict our analysis to an examination of a single year's cash flow. In practice, however, cash flows vary year by year, and most real estate investors calculate their return by analyzing the income generated over several years along with the gain realized from sale of the property.

Many of the new federal tax provisions apply only to property placed in service after 1986. Thus, because we have chosen to assume that our prototypes remain under the same ownership, the after tax cash flows do not reflect the effect of changes in the depreciation schedule, the alternative minimum tax, at-risk rules, or the capital gains tax.

The key tax reform provisions that will affect the cash flow of the prototypes are the lowered tax brackets and the new restrictions on passive losses. Lower tax brackets will result in a higher ATCF for buildings that currently generate a positive taxable income and a lower ATCF for those that now yield a negative taxable income.

In most of the prototypes, tax losses contribute a large share of the after tax cash flows. The Tax Reform Act imposes restrictions on such tax shelters, allowing the taxpayer to deduct losses from "passive activities" only to the extent that the loss offsets passive income. By definition, the tax code considers investment in rental property to be a passive activity. Under the new law real estate investment losses may be used to offset other income only when an investor is significantly involved in property management decisions. In addition, the deduction is limited to $25,000 per year. The $25,000 allowance is phased out for income levels beginning at $100,000.

The after tax cash flows shown in our pro formas assume that the tax loss is fully deductible. After 1986, this will not always be true, but will be possible either when the loss is allocated at up to $25,000 each to actively involved owners or when building investors who are not involved in management use the loss to offset income from other rental property. It should be noted that when the taxable income generated by the building is negative, the ATCF equals the BTCF for buildings that are owned by individuals with no other income or by nonprofits that pay no tax. People with limited incomes will make little use of the tax shelter aspect of real estate.

8. The final element of the economic prototypes is the introduction of seismic upgrading costs and the calculation of their impacts on the buildings' net cash flows. Because the cost will vary with the level of upgrading required, we examine three alternatives. Generally speaking, the absolute minimal upgrade is a wall anchorage system which costs about $6 per square foot. Some additional shear bracing in the ground floor commercial space adds about $5 per square foot to this figure in those buildings which have such spaces. For four-story buildings, Level 1 upgrading costs $16 per square foot and Level 2 upgrading costs $21 per square foot. For five and six-story buildings, the costs increase to $21 per square foot for Level 1 upgrading and to $25 per square foot for Level 2 work.[1] When these figures (which are fully explained in Chapter III and the Engineering Appendix) are added to the protoype pro formas, it is possible to derive net cash flow remaining after each level of prospective upgrading. To calculate debt service on upgrade loans we use the 10%, ten year terms governing rent passthroughs allowed under San Francisco's rent control ordinance. Actual finance terms may differ.

The pro forma analysis allows one to examine the impact that seismic upgrading requirements would have on building owners if subsidies are unavailable and in circumstances when rental market conditions force owners to absorb the expense. It is likely, however, that in most cases, rent increases will result. San Francisco's rent control ordinance allows the cost of building improvements to be passed on to tenants. The law provides for a ten year amortization period at 10% interest (unless a lower interest rate is obtained through federal financing programs). Under these rules, the allowable passthrough amounts to $13.22 per month for each $1000 of upgrade expense.

Table 11 shows the allowable monthly per unit rent increase for a range of improvement costs. The impact of these costs upon current rents is shown in tables following each pro forma.

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[1] Level 1 upgrading is the equivalent of the Los Angeles requirements for Class III and IV, medium and low risk buildings with occupancy of less than 100 people. Level 2 is the equivalent of the Los Angeles requirements for Class II, non-essential buildings having an occupant load of 100 or more. This is the same as the maximum requirement of the 1973 UBC which is the current San Francisco code for substantial rehabilitation.

UPGRADE COST PER UNIT	AMORTIZATION PERIOD	INTEREST RATE	MONTHLY PASSTHROUGH PER UNIT
$1,000	10 YEARS	10%	$13.22
$2,000	10 YEARS	10%	$26.43
$3,000	10 YEARS	10%	$39.65
$4,000	10 YEARS	10%	$52.86
$5,000	10 YEARS	10%	$66.08
$6,000	10 YEARS	10%	$79.29
$7,000	10 YEARS	10%	$92.51
$8,000	10 YEARS	10%	$105.72
$9,000	10 YEARS	10%	$118.94
$10,000	10 YEARS	10%	$132.15
$11,000	10 YEARS	10%	$145.37
$12,000	10 YEARS	10%	$158.58
$13,000	10 YEARS	10%	$171.80
$14,000	10 YEARS	10%	$185.01
$15,000	10 YEARS	10%	$198.23

TABLE 11
Monthly Rent Passthrough Allowed Under the San Francisco Rent Control Ordinance

FINANCIAL PROTOTYPES

In this section, financial pro formas representing seven typical unreinforced masonry buildings are presented. As described above, these statements include information about building income, operating expenses, and debt service. In addition, the prototypes include a calculation of the current before and after tax cash flow for five building finance scenarios. Cash flow calculations are then provided for three seismic upgrade alternatives. Finally, we show the impact of seismic upgrading upon residential rents in each building.

BUILDING C-1

Prototype C-1 is a small Chinatown residential hotel. On the upper levels, this three-story building has fourteen rooms whose dimensions average 120 square feet and which rent for an average $160 per month. Along with the sleeping rooms, the upper floors contain communal kitchens and baths. Because we have placed this building on busy Stockton Street, the 1300 square feet of ground floor commercial space rent for $4 per square foot.

As is common in the Chinatown neighborhood, commercial rent represents a significant portion of the building's revenue. In this case, the ground floor space contributes 71% of the total income. There are three principal reasons for this. First, many of the elderly tenants in Chinatown hotels have occupied the same unit for a long period of time. Due to the slow rate of turnover (average tenure is ten to fifteen years), rents have remained low. In addition, longtime building owners often have little or no debt service and can therefore afford to provide below-market rate residential units. It is common for family and district associations (which own about 20% of the Chinatown residential hotels) to provide low cost housing for their members. Finally, because shop owners are willing to pay a premium to locate in Chinatown and on Stockton Street, the building generates substantial commercial revenue.

As is typical in the Chinatown neighborhood, the vacancy/collection loss rate is low at an average 3% of gross possible income.

This building is representative of a type common in Chinatown. The core Chinatown neighborhood contains approximately 85 unreinforced masonry residential hotels.[2] One-fifth of these are located along Stockton and Grant Streets, the district's busiest commercial streets. Fifty-five percent of the area's URM residential hotels have fewer than twenty units, and sixty-five percent of URM residential buildings in this neighborhood are three stories or less in height.

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[2] The Chinatown "core" is the area described in the City Planning Department's Chinatown Rezoning study.

Impact of Seismic Ordinance on Owner

Faced with a seismic upgrade requirement, the owner of this building may face an incentive to remove residential units from the market. It has been reported that because commercial space brings in higher revenue, because operating expenses and management needs are less for commercial space, and because code regulations are less stringent, some owners find it more profitable to lease residential units as storage space.

If one assumes, as is common in Chinatown, that this building has been under the same ownership for many years, the debt service is low, therefore the cash flow is positive and sufficient to cover seismic upgrading. However, one must remember that many Chinatown buildings are not owned by typical real estate investors. In contrast to investment properties located elsewhere, this building may provide the owner's sole source of income. In addition, it is likely that the owner's initial equity investment was greater than for the typical income-producing property, therefore the actual rate of return may be less than the cash flow implies.[3]

Impact on Tenants

A wall anchorage upgrade for this building will cost approximately $25,000. Under this option, a $4,000 annual expense passthrough is allowed under the current rent control law. This amounts to a $24 monthly rent increase per unit and represents a 15% increase over the building's current average rents.

In contrast, a Level 1 upgrade will cost nearly $67,000, and will result in a $10,800 annual passthrough. This amounts to an average per unit monthly rent increase of $63, a 39% increase over current rents.

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[3] According to real estate brokers familiar with Chinatown investments, downpayments amounting to 40% of the purchase price are common in the area. This compares to the 20% downpayment that is typical for most investment properties.

PROTOTYPE #	C-1
NEIGHBORHOOD	CHINATOWN
OWNERSHIP	PRIVATE
BUILDING TYPE	RESIDENTIAL HOTEL GROUND FLOOR COMMERCIAL ON STOCKTON STREET
# STORIES	3 NO ELEVATOR
TOTAL BUILDING AREA (1)	4,182 SQFT
# RES. UNITS	14 ROOMS
RESIDENTIAL RENT	$160 /ROOM/MONTH
COMMERCIAL AREA	1,300 SQFT
COMM. RENT	$4.00 SQFT/MO

(1) Building area is calculated as follows:

7 rooms per floor @ 120 square feet = 840 sf
x 1.66 circulation and common room factor = 1394 sf
x 3 floors = 4182 sf

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE C-1

		(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential		$26,880	$26,880	$26,880	$26,880	$26,880
1986 Gross Income - Commercial		$62,400	$62,400	$62,400	$62,400	$62,400
GROSS POSSIBLE INCOME		$89,280	$89,280	$89,280	$89,280	$89,280
(Less) Vacancy/Bad Debt	(2)	($2,700)	($2,700)	($2,700)	($2,700)	($2,700)
EFFECTIVE GROSS INCOME		$86,580	$86,580	$86,580	$86,580	$86,580
(Less) Operating Expenses	(3)	($22,846)	($22,846)	($22,846)	($22,846)	($22,846)
(Less) Real Estate Taxes	(4)	($5,617)	($5,617)	($5,617)	($9,173)	($11,087)
Expenses and Taxes: Per Room		2033	2033	2033	2287	2424
Expenses and Taxes: as % of EGI		33%	33%	33%	35%	39%
NET OPERATING INCOME		$58,117	$58,117	$58,117	$54,561	$52,648
(Less) Current Debt Service	(5)	0	(17,799)	(25,740)	(45,528)	(45,776)
BEFORE TAX CASH FLOW		58,117	40,319	32,377	$9,033	6,872
1986 Depreciation Deduction	(6)	0	$6,430	$8,504	$39,450	$68,464
1986 Interest Deduction		0	$12,603	$21,688	$41,270	$43,176
TAXABLE INCOME		58,117	$39,084	$27,925	($26,159)	($58,992)
(Less) Tax						
15% Bracket		($8,718)	($5,863)	($4,189)	($3,924)	($8,849]
22% Bracket		($12,786)	($8,599)	($6,144)	($5,755)	($12,978)
50% Bracket		($29,059)	($19,542)	($13,963)	($13,080)	($29,496)
AFTER TAX CASH FLOW						
15% Bracket		$49,400	$34,456	$28,188	$12,957	$15,721
22% Bracket		$45,332	$31,720	$26,234	$14,788	$19,850
50% Bracket		$29,059	$20,776	$18,414	$22,113	$36,368

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.
(2) Vacancy/Bad Debt Allowance is calculated at 3% of residential gross and 3% of commercial gross.
(3) Operating Expenses are calculated using the methods described in Section IV.
(4) Real Estate Taxes are 1.14% of 1986 assessed value.
(5) Debt Service is based on mortgage terms in the year of purchase as explained in Section V.
(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971, 1976, and 1981 to maximize deduction.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	$321,500	$425,200	$736,000	$972,500
Maximum Loan/Value Ratio		60%	60%	60%	60%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$192,900	$255,100	$441,600	$444,000
% of Purchase Price		60%	60%	60%	46%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30 yrs
DEBT SERVICE		($17,799)	($25,740)	($45,528)	($45,776)
Depreciation Method	(5)	40 yrs	40 yrs	15 yrs	19 yrs
Acceleration (if applicable)		125%	125%	175%	175%
Initial Depreciable Basis	(6)	$257,200	$340,160	$588,800	$778,000

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(1) Purchase price is calculated by the method described in Section V.

(2) Mortgage amount is the lesser of a 60% loan-to-value ratio or a 1.15% debt coverage ratio. (Loan-to-value ratios in Chinatown are commonly lower than the 80% used in the other two prototype areas.)

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 mortgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method in effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE   Prototype C-1

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 4,182 sf					
TOTAL COST: $25,092					
Current Debt Serice	$0	($17,799)	($25,740)	($45,528)	($45,776)
Upgrade Debt Service (1)	($3,979)	($3,979)	($3,979)	($3,979)	($3,979)
Total Debt Service	($3,979)	($21,778)	($29,719)	($49,507)	($49,755)
BEFORE TAX CASH FLOW	$54,138	$36,339	$28,398	$5,054	$2,893
AFTER TAX CASH FLOW					
15% Bracket	$45,802	$30,858	$24,590	$9,344	$12,123
22% Bracket	$41,911	$28,300	$22,813	$11,346	$16,430
50% Bracket	$26,350	$18,067	$15,705	$$19,354	$33,659
LEVEL 1					
Cost/sf $16					
Building Size: 4,182 sf					
TOTAL COST: $66,912					
Current Debt Service	$0	($17,799)	($25,740)	($45,528)	($45,776)
Upgrade Debt Service (1)	($10,611)	($10,611)	($10,611)	($10,611)	($10,611)
Total Debt Service	($10,611)	($28,410)	($36,351)	($56,139)	($56,387)
BEFORE TAX CASH FLOW	$47,506	$29,708	$21,766	($1,578)	($3,739)
AFTER TAX CASH FLOW					
15% Bracket	$39,765	$24,821	$18,553	$3,322	$6,086
22% Bracket	$36,152	$22,540	$17,054	$5,608	$10,671
50% Bracket	$21,701	$13,418	$11,056	$14,754	$29,010
LEVEL 2					
Cost/sf $21					
Building Size: 4,182 sf					
TOTAL COST: $87,822					
Current Debt Serice	$0	($17,799)	($25,740)	($45,528)	($45,776)
Upgrade Debt Service (1)	($13,927)	($13,927)	($13,927)	($13,927)	($13,927)
Total Debt Service	($13,927)	($31,726)	($39,667)	($59,455)	($59,703)
BEFORE TAX CASH FLOW	$44,190	$26,392	$18,450	($4,894)	($7,055)
AFTER TAX CASH FLOW					
15% Bracket	$36,754	$21,810	$15,542	$311	$3,075
22% Bracket	$33,283	$19,672	$14,185	$2,740	$7,802
50% Bracket	$19,401	$11,119	$8,757	$12,456	$26,711

(1) Seismic upgrades financed with 10-year improvement loan at 10%.

BUILDING C-1

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$25,092	$1,792	$24	$184	15%
LEVEL 1	$16	$66,912	$4,779	$63	$223	39%
LEVEL 2	$21	$87,822	$6,273	$83	$243	52%

BUILDING C-2

Prototype C-2 represents a twelve units, three-story Chinatown apartment building with rents averaging $235 for studios and $265 for one-bedroom apartments. These very low rents are explained by the fact that tenant turnover is even less for apartments than for Chinatown's residential hotel units. Because we have located this building on a side street away from the neighborhood's busy shopping streets, the ground floor commercial space, which amounts to 2150 square feet, rents for $2 per square foot. The commercial portion of this building contributes 58% of the total revenue. As in prototype C-1, the vacancy/collection loss rate is 3%.

This building represents a typical Chinatown apartment building. Sixty-five percent of Chinatown URM apartment buildings are of three stories or less and 25% have between seven and twelve units.

The owner and tenants in this building face impacts similar to those outlined for building C-1.

PROTOTYPE #	C-2
NEIGHBORHOOD	CHINATOWN
OWNERSHIP	PRIVATE
BUILDING TYPE	APARTMENTS GROUND FLOOR COMMERCIAL NOT ON STOCKTON STREET
# STORIES	3 NO ELEVATOR
TOTAL BUILDING AREA (1)	6,750 SF
# RES. UNITS	4 STUDIOS 8 1-BEDROOMS
RESIDENTIAL RENT	$235 /STUDIO/MONTH $265 /1-BR /MONTH
COMMERCIAL AREA	2,150 SQFT
COMM. RENT	$2.00 SQFT/MO

(1) Building area is calculated as follows:

2 studios @ 250 sf and 4 1BR @ 300 sf = 1800 sf per floor
x 1.25 circulation and common room factor = 2250 sf per floor
x 3 floors = 6750 sf TOTAL

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE C-2

		(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential		$36,720	$36,720	$36,720	$36,720	$36,720
1986 Gross Income - Commercial		$51,600	$51,600	$51,600	$51,600	$51,600
GROSS POSSIBLE INCOME		$88,320	$88,320	$88,320	$88,320	$88,320
(Less) Vacancy/Bad Debt	(2)	($2,600)	($2,600)	($2,600)	($2,600)	($2,600)
EFFECTIVE GROSS INCOME		$85,720	$85,720	$85,720	$85,720	$85,720
(Less) Operating Expenses	(3)	($21,205)	($21,205)	($21,205)	($21,205)	($21,205)
(Less) Real Estate Taxes	(4)	($7,313)	($7,313)	($7,313)	($9,471)	($10,766)
Expenses and Taxes: Per Unit		2,376	2,376	2,376	2,556	2,664
Expenses and Taxes: as % of EGI		33%	33%	33%	36%	37%
NET OPERATING INCOME		$57,202	$57,202	$57,202	$55,044	$53,749
(Less) Current Debt Service	(5)	0	(21,886)	(33,863)	(47,003)	(46,735)
BEFORE TAX CASH FLOW		57,202	35,316	23,339	8,041	7,014
1986 Depreciation Deduction	(6)	0	$7,906	$11,188	$40,731	$66,486
1986 Interest Deduction		0	$15,498	$28,531	$42,664	$44,314
TAXABLE INCOME		57,202	$33,798	$17,483	($28,351)	($57,051)
(Less) Tax						
15% Bracket		($8,580)	($5,070)	($2,622)	$4,253	$8,558
22% Bracket		($12,584)	($7,436)	($3,846)	$6,237	$12,551
50% Bracket		($28,601)	($16,899)	($8,742)	$14,175	$28,526
AFTER TAX CASH FLOW						
15% Bracket		$48,622	$30,246	$20,717	$12,294	$15,572
22% Bracket		$44,618	$27,880	$19,493	$14,279	$19,565
50% Bracket		$28,601	$18,417	$14,598	$22,217	$35,540

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.

(2) Vacancy/Bad Debt Allowance is calculated at 4% of residential gross.

(3) Operating Expenses are calculated using the methods described in Section IV.

(4) Real Estate Taxes are 1.14% of 1986 assessed value.

(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.

MORTGAGE AND DEPRECIATION CALCULATION

	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE (1)	$395,300	$559,400	$759,900	$944,400
Maximum Loan/Value Ratio	60%	60%	60%	60%
Minimum Debt Coverage Ratio	1.15	1.15	1.15	1.15
MORTGAGE AMOUNT (2)	$237,200	$335,600	$455,900	$453,300
% of Purchase Price	60%	60%	60%	48%
Interest Rate (3)	8.50%	9.50%	9.75%	9.75%
Amortization Period (4)	30 yrs	30 yrs	30 yrs	30 yrs
DEBT SERVICE	($21,886)	($33,863)	($47,003)	($46,735)
Depreciation Method (5)	40 yrs	40 yrs	15 yrs	19 yrs
Acceleration (if applicable)	125%	125%	175%	175%
Initial Depreciable Basis (6)	$316,240	$447,520	$607,920	$755,520

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(1) Purchase Price is calculated by the method described in Section V.

(2) Mortgage amount is calculated as the lesser of an 60% loan-to-value ratio or a 1.15% debt coverage ratio. (Loan-to-value ratios in Chinatown are commonly lower than the 80% used in the two other prototype areas.)

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 mortgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE   Prototype C-2

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 6,750 sf					
TOTAL COST: $40,500					
Current Debt Serice	$0	($21,886)	($33,863)	($47,003)	($46,735)
Upgrade Debt Service (1)	($6,423)	($6,423)	($6,423)	($6,423)	($6,423)
Total Debt Service	($6,423)	($28,309)	($40,285)	($53,425)	($53,157)
BEFORE TAX CASH FLOW	$50,780	$28,893	$16,917	$1,619	$592
AFTER TAX CASH FLOW					
15% Bracket	$42,790	$24,414	$14,885	$6,462	$9,740
22% Bracket	$39,062	$22,324	$13,937	$8,722	$14,009
50% Bracket	$24,148	$13,963	$10,144	$17,763	$31,086
LEVEL 1					
Cost/sf $16					
Building Size: 6,750 sf					
TOTAL COST: $108,000					
Current Debt Service	$0	($21,886)	($33,863)	($47,003)	($46,735)
Upgrade Debt Service (1)	($17,127)	($17,127)	($17,127)	($17,127)	($17,127)
Total Debt Service	($17,127)	($39,013)	($50,990)	($64,129)	($63,861)
BEFORE TAX CASH FLOW	$40,075	$18,189	$6,213	($9,085)	($10,113)
AFTER TAX CASH FLOW					
15% Bracket	$33,070	$14,695	$5,165	($3,258)	$20
22% Bracket	$29,801	$13,064	$4,676	($538)	$4,749
50% Bracket	$16,725	$6,540	$2,721	$10,341	$23,663
LEVEL 2					
Cost/sf $21					
Building Size: 6,750 sf					
TOTAL COST: $141,750					
Current Debt Serice	$0	($21,886)	($33,863)	($47,003)	($46,735)
Upgrade Debt Service (1)	($22,479)	($22,479)	($22,479)	($22,479)	($22,479)
Total Debt Service	($22,479)	($44,365)	($56,342)	($69,481)	($69,213)
BEFORE TAX CASH FLOW	$34,723	$12,837	$860	($14,437)	($15,465)
AFTER TAX CASH FLOW					
15% Bracket	$28,210	$9,835	$305	($8,117)	($4,840)
22% Bracket	$25,171	$8,434	$46	($5,168)	$119
50% Bracket	$13,014	$2,829	($990)	$6,629	$19,952

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.
(2) Vacancy/Bad Debt Allowance is calculated at 3% of residential gross and 3% of commercial gross.
(3) Operating Expenses are calculated using the methods described in Section IV.
(4) Real Estate Taxes are 1.14% of 1986 assessed value.
(5) Debt Service is based on mortgage terms in the year of purchase as explained in Section V.
(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971, 1976, and 1981 to maximize deduction.

BUIDLING C-2

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$40,500	$3,375	$38	$273-303	14-16%
LEVEL 1	$16	$108,000	$9,000	$119	$354-384	45-51%
LEVEL 2	$21	$141,750	$11,813	$156	$391-421	59-66%

BUILDING C-3

Prototype C-3 is a 48 room, 4-story Chinatown residential hotel. Because we have assigned ownership of this building to a nonprofit organization, rents are below ground floor commercial space. As is typical for nonprofit used to cover operating expenses. Because nonprofits generally plan for long-term building ownership, they typically spend more for maintenance. Furthermore, nonprofits often provide additional staff and services and therefore have higher management costs. Although this building's expense/income ratio is higher than for the other two Chinatown prototypes, the per units cost is lower, reflecting the economy of scale achieved in this larger building.

For our prototype, we have assumed that sixty percent of this building's purchase price has been cover by grants or deferred-interest loans. As has been common for nonprofit housing developments, only forty percent of the scales price is assumed to have been financed under conventional mortgage terms. Even with these assumptions, buildings purchased recently appear to have cash shortfalls in amounts which are probably covered by government or foundation grants.

Impact on owner and Tenants

As described above, recently purchased nonprofit buildings are likely to already sustain negative cash flows. Buildings under this form of ownership will almost certainly require some additional subsidy in order to comply with a seismic upgrade ordinance.

Nonprofit housing organizations provide rental units at substantially reduced levels, and tenants in these buildings generally have very low incomes. Any rent increase is bound to impose a burden on them.

PROTOTYPE #	C-3
NEIGHBORHOOD	CHINATOWN
OWNERSHIP	NON-PROFIT
BUILDING TYPE	RESIDENTIAL HOTEL GROUND FLOOR COMMERCIAL NOT ON STOCKTON STREET
# STORIES	4 NO ELEVATOR
TOTAL BUILDING AREA (1)	12,750 SQFT
# RES. UNITS	48 ROOMS
RESIDENTIAL RENT	$140 /ROOM/MONTH
COMMERCIAL AREA	3,100 SQFT
COMM. RENT	$1.50 SQFT/MO

(1) Building area is calculated as follows:

16 rooms per floor @ 120 sf = 1920 sf
x 1.66 circulation and common room factor = 3187 sf
x 4 floors = 12,478 sf

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE

	(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential	$80,640	$80,640	$80,640	$80,640	$80,640
1986 Gross Income - Commercial	$55,800	$55,800	$55,800	$55,800	$55,800
GROSS POSSIBLE INCOME	$136,440	$136,440	$136,440	$136,440	$136,440
(Less) Vacancy/Bad Debt (2)	($4,100)	($4,100)	($4,100)	($4,100)	($4,100)
EFFECTIVE GROSS INCOME	$132,340	$132,340	$132,340	$132,340	$132,340
(Less) Operating Expenses (3)	($59,455)	($59,455)	($59,455)	($59,455)	($59,455)
(Less) Real Estate Taxes (4)	($9,943)	($9,943)	($9,943)	($19,262)	($23,783)
Expenses and Taxes: Per Unit	1446	1446	1446	1640	1734
Expenses and Taxes: as % of EGI	52%	52%	52%	59%	63%
NET OPERATING INCOME	$62,942	$62,942	$62,942	$53,623	$49,102
(Less) Current Debt Service (5)	0	(20,513)	(30,695)	(46,631)	(42,693)
BEFORE TAX CASH FLOW	62,942	42,429	32,248	6,992	6,409
1986 Depreciation Deduction (6)	0	$11,116	$15,212	$86,548	$221,972
1986 Interest Deduction	0	$14,525	$25,862	$42,327	$40,268
TAXABLE INCOME (7)	62,942	$37,301	$21,868	($75,252)	($213,137)
(Less) Tax					
15% Bracket	($9,441)	($5,595)	($3,280)	$11,288	$31,971
22% Bracket	($13,847)	($8,206)	($4,811)	$16,555	$46,890
50% Bracket	($31,471)	($18,651)	($10,934)	$37,626	$106,569
AFTER TAX CASH FLOW					
15% Bracket	$53,501	$36,834	$28,967	$18,280	$38,380
22% Bracket	$49,095	$34,223	$27,437	$23,547	$53,299
50% Bracket	$31,471	$23,778	$21,314	$44,618	$112,978

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.
(2) Vacancy/Bad Debt Allowance is calculated at 4% of residential gross.
(3) Operating Expenses are calculated using the methods described in Section IV.
(4) Real Estate Taxes are 1.14% of 1986 assessed value.
(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.
(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971 and 1976 to maximize deduction.
(7) Tax deductions are shown to demonstrate tax benefits passed through to limited partners if property is syndicated.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	$555,800	$760,600	$1,545,500	$2,086,200
Maximum Loan/Value Ratio		40%	40%	20%	20%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$222,320	$304,200	$309,100	$414,100
Actual Loan/Value		40%	40%	20%	20%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
DEBT SERVICE		($20,513)	($30,695)	($31,868)	($42,693)
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30
Depreciation Method	(5)	40 yrs	40 yrs	15 yrs	19
Acceleration (if applicable)		125%	125%	175%	175%yrs
Initial Depreciable Basis	(6)	$444,640	$608,480	$1,236,400	$1,668,960 yrs

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(1) Purchase price is calculated by method described in Section V.

(2) Mortgage amount is 40% of purchase price in 1971 and 1976 and 20% of purchase price in 1981 and 1986.

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 motgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE Prototype C-3

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 12,750 sf					
TOTAL COST: $76,500					
Current Debt Serice	$0	($20,513)	($30,695)	($31,868)	($42,693)
Upgrade Debt Service (1)	($12,131)	($12,131)	($12,131)	($12,131)	($12,131)
Total Debt Service	($12,131)	($32,645)	($42,826)	($43,999)	($54,825)
BEFORE TAX CASH FLOW	$50,811	$30,297	$20,116	$9,624	($5,722)
AFTER TAX CASH FLOW					
15% Bracket	$42,493	$25,825	$17,959	$22,035	$27,372
22% Bracket	$38,611	$23,738	$16,953	$27,827	$42,815
50% Bracket	$23,084	$15,391	$12,926	$50,994	$104,590
LEVEL 1					
Cost/sf $16					
Building Size: 12,750 sf					
TOTAL COST: $204,000					
Current Debt Service	$0	($20,513)	($30,695)	($31,868)	($42,693)
Upgrade Debt Service (1)	($32,351)	($32,351)	($32,351)	($32,351)	($32,351)
Total Debt Service	($32,351)	($52,864)	($63,045)	($64,218)	($75,044)
BEFORE TAX CASH FLOW	$30,592	$10,078	($103)	($10,595)	($25,941)
AFTER TAX CASH FLOW					
15% Bracket	$24,126	$7,459	($408)	$3,668	$9,005
22% Bracket	$21,109	$6,236	($550)	$10,325	$25,313
50% Bracket	$9,039	$1,346	($1,118)	$36,949	$90,546
LEVEL 2					
Cost/sf $21					
Building Size: 12,750 sf					
TOTAL COST: $267,750					
Current Debt Serice	$0	($20,513)	($30,695)	($31,868)	($42,693)
Upgrade Debt Service (1)	($42,460)	($42,460)	($42,460)	($42,460)	($42,460)
Total Debt Service	($42,460)	($62,973)	($73,155)	($74,328)	($85,153)
BEFORE TAX CASH FLOW	$20,482	($31)	($10,212)	($20,705)	($36,051)
AFTER TAX CASH FLOW					
15% Bracket	$14,946	($1,721)	($9,587)	($5,511)	($175)
22% Bracket	$12,363	($2,510)	($9,295)	$1,579	$16,567
50% Bracket	$2,029	($5,664)	($8,128)	$29,939	$83,536

(1) Seismic upgrades financed with 10-year improvement loan at 10%.

BUILDING C-3

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$76,500	$1,594	$21	$161	15%
LEVEL 1	$16	$204,000	$4,250	$56	$196	40%
LEVEL 2	$21	$267,750	$5,578	$74	$214	53%

BUILDING T-1

Prototype T-1 represents a 100 room, five-story Tenderloin residential hotel. In comparison to those in the Chinatown area, rooms in hotels in the Tenderloin neighborhood typically are larger, and many have private or shared baths. In addition, ground floor lobbies are common in Tenderloin hotels, whereas in Chinatown, ground floor space is more often exclusively devoted to commercial use.

Residential rents are higher in this neighborhood, in part because the rate of turnover is substantially higher. (San Francisco's rent control ordinance does not limit rent increases when units become vacant.) For this prototype, monthly rent averages $285 per unit. The 3500 square feet of ground floor commercial space rent for $1 per square foot. Due to higher turnover in this neighborhood, the vacancy/loss factor is six percent.

Representing one of the 85 URM residential hotels in the core Tenderloin census tracts, this building is of a type common in this neighborhood. Forty-four percent of the URM residential buildings in the neighborhood are five or more stories. For these buildings, the cost of Level 1 upgrading is $5 greater per square foot than for four-story or shorter buildings. Level 2 upgrading for a five-story building costs an additional $4 per square foot.

Impact on Owner and Tenants

With a healthy positive cash flow, this prototype appears to be a profitable investment under all five finance options we have examined.[4] A wall anchorage upgrade for this building would cost a total of $176,400, resulting in an allowable monthly rent increase of $23 per unit, an increase of 8% over current average rents. In comparison, a Level 1 upgrade would result in 29% rent increases equalling $82 per unit per month. It should be noted, however, that those tenants who have recently moved into units in this building are likely to be paying rent at levels $50 to $75 above the average rent used for this prototype. For recently occupied units, the rent increases necessitated by seismic upgrade may push the asking price above the market-rate rent for comparable units.

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[4] As it yields a 10% cap rate, the 1986 sale price that results from our projection model may be an understimation.

PROTOTYPE #	T-1
NEIGHBORHOOD	TENDERLOIN
OWNERSHIP	PRIVATE
BUILDING TYPE	RESIDENTIAL HOTEL GROUND FLOOR COMMERCIAL
# STORIES	5 WITH ELEVATOR
TOTAL BUILDING AREA (1)	29,400 SQFT
# RES. UNITS	100 ROOMS
RESIDENTIAL RENT	$285 /RM/MO
COMMERCIAL AREA	3,500 SQFT
COMM. RENT	$1.00 SQFT/MO

(1) Building area calculated as follows:

25 rooms per floor @ 168 sf = 4200 sf per floor
x 1.4 circulation/common room factor = 5880 sf per floor
x 5 floors = 29400 sf TOTAL

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE T-1

	(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential	$342,000	$342,000	$342,000	$342,000	$342,000
1986 Gross Income - Commercial	$42,000	$42,000	$42,000	$42,000	$42,000
GROSS POSSIBLE INCOME	$384,000	$384,000	$384,000	$384,000	$384,000
(Less) Vacancy/Bad Debt (2)	($31,560)	($31,560)	($31,560)	($31,560)	($31,560)
EFFECTIVE GROSS INCOME	$352,440	$352,440	$352,440	$352,440	$352,440
(Less) Operating Expenses (3)	($129,642)	($129,642)	($129,642)	($129,642)	($129,642)
(Less) Real Estate Taxes (4)	($8,834)	($8,834)	($8,834)	($17,065)	($22,727)
Expenses and Taxes: Per Unit	1385	1385	1385	1467	1524
Expenses and Taxes: as % of EGI	39%	39%	39%	42%	43%
NET OPERATING INCOME	$213,964	$213,964	$213,964	$205,734	$200,071
(Less) Current Debt Service (5)	0	(38,783)	(51,824)	(112,930)	(164,430)
BEFORE TAX CASH FLOW	213,964	175,182	162,141	92,804	35,642
1986 Depreciation Deduction (6)	0	$10,508	$12,840	$73,389	$140,349
1986 Interest Deduction	0	$27,463	$43,665	$102,507	$155,005
TAXABLE INCOME	213,964	$175,993	$157,459	$29,838	($95,283)
(Less) Tax					
15% Bracket	($32,095)	($26,399)	($23,619)	($4,476)	$14,292
22% Bracket	($47,072)	($38,719)	($34,641)	($6,564)	$20,962
50% Bracket	($106,982)	($87,997)	($78,730)	($14,919)	$47,642
AFTER TAX CASH FLOW					
15% Bracket	$181,870	$148,783	$138,522	$88,328	$49,934
22% Bracket	$166,892	$136,463	$127,500	$86,240	$56,604
50% Bracket	$106,982	$87,185	$83,411	$77,885	$83,283

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.
(2) Vacancy/Bad Debt Allowance is calculated at 8% of residential gross (higher than normal due to size of building) and 10% of commercial gross.
(3) Operating Expenses are calculated using the methods described in Section IV.
(4) Real Estate Taxes are 1.14% of 1986 assessed value.
(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.

(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971, 1976, and 1981 to maximize deduction.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	525,400	642,000	1,369,200	1,993,600
Maximum Loan/Value Ratio		80%	80%	80%	80%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$420,320	$513,600	$1,095,360	$1,594,880
Actual Debt Coverage		80%	80%	80%	80%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30 yrs
DEBT SERVICE		($38,783)	($51,824)	($112,930)	($164,430)
Depreciation Method	(5)	40 yrs 125%	40 yrs 125%	15 yrs 175%	19 yrs 175%
Initial Depreciable Basis	(6)	$420,320	$513,600	$1,095,360	$1,594,880

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(1) Purchase price is calculated by the method described in Section V.

(2) Mortgage amount is calculated as the lesser of an 80% loan-to-value ratio or a 1.15% debt coverage ratio.

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 motgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE   Prototype T-1

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 29,400 sf					
TOTAL COST: $176,400					
Current Debt Serice	$0	($38,783)	($51,824)	($112,930)	($164,430)
Upgrade Debt Service (1)	($27,974)	($27,974)	($27,974)	($27,974)	($27,974)
Total Debt Service	($27,974)	($66,756)	($79,797)	($140,904)	($192,403)
BEFORE TAX CASH FLOW	$185,991	$147,208	$134,167	$64,830	$7,668
AFTER TAX CASH FLOW					
15% Bracket	$156,469	$123,382	$113,121	$62,928	$24,533
22% Bracket	$142,692	$112,263	$103,300	$62,040	$32,404
50% Bracket	$87,585	$67,788	$64,014	$58,488	$63,886
LEVEL 1					
Cost/sf $21					
Building Size: 29,400 sf					
TOTAL COST: $617,400					
Current Debt Service	$0	($38,783)	($51,824)	($112,930)	($164,430)
Upgrade Debt Service (1)	($97,908)	($97,908)	($97,908)	($97,908)	($97,908)
Total Debt Service	($97,908)	($136,691)	($149,731)	($210,838)	($262,338)
BEFORE TAX CASH FLOW	$116,056	$77,274	$64,233	($5,104)	($62,266)
AFTER TAX CASH FLOW					
15% Bracket	$92,967	$59,880	$49,619	($574)	($38,969)
22% Bracket	$82,192	$51,763	$42,800	$1,539	($28,096)
50% Bracket	$39,092	$19,295	$15,521	$9,995	$15,393
LEVEL 2					
Cost/sf $25					
Building Size: 29,400 sf					
TOTAL COST: $735,000					
Current Debt Serice	$0	($38,783)	($51,824)	($112,930)	($164,430)
Upgrade Debt Service (1)	($116,557)	($116,557)	($116,557)	($116,557)	($116,557)
Total Debt Service	($116,557)	($155,340)	($168,380)	($229,487)	($280,987)
BEFORE TAX CASH FLOW	$97,407	$58,625	$45,584	($23,753)	($80,915)
AFTER TAX CASH FLOW					
15% Bracket	$76,033	$42,946	$32,686	($17,508)	($55,902)
22% Bracket	$66,059	$35,630	$26,666	($14,594)	($44,229)
50% Bracket	$26,161	$6,363	$2,590	($2,936)	$2,462

(1) Debt service on upgrade costs is calculated as a 10-year loan at 10%.

BUILDING T-1

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$176,400	$1,764	$23	$308	8%
LEVEL 1	$21	$617,400	$6,174	$82	$367	29%
LEVEL 2	$25	$735,000	$7,350	$97	$382	34%

BUILDING T-2

Prototype T-2 is a five story Tenderloin building containing 40 studio apartments that rent at an average $380 per month. The building has no commercial space. As in prototype T-1, the vacancy/loss factor is six percent.

Impact on Owner

Rents from this building do not support a mortgage of 80% of the 1986 estimated purchase price; therefore, the building would not be able to support the additional debt service required for seismic upgrading. However, in contrast to the long-term ownership common to individuals and family associations in Chinatown, the investment scenario typical for building of this sort may involve equity contributions from a number of partners who share in the income and tax losses generated by the building.

PROTOTYPE #	T-2
NEIGHBORHOOD	TENDERLOIN
OWNERSHIP	PRIVATE
BUILDING TYPE	APARTMENTS NO COMMERCIAL
# STORIES	5 WITH ELEVATOR
TOTAL BUILDING AREA (1)	13,750 SQFT
# RES. UNITS	40 STUDIOS
RESIDENTIAL RENT	$380 /STUDIO/MONTH
COMMERCIAL AREA	0 SQFT
COMM. RENT	SQFT/MO

(1) Building area is calculated as follows:

40 studios @ 275 sf	= 11000 sf
x 1.25 circulation factor	= 13750 sf TOTAL

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE T-2

		(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential		$182,400	$182,400	$182,400	$182,400	$182,400
1986 Gross Income - Commercial		$0	$0	$0	$0	$0
GROSS POSSIBLE INCOME		$182,400	$182,400	$182,400	$182,400	$182,400
(Less) Vacancy/Bad Debt	(2)	($10,900)	($10,900)	($10,900)	($10,900)	($10,900)
EFFECTIVE GROSS INCOME		$171,500	$171,500	$171,500	$171,500	$171,500
(Less) Operating Expenses	(3)	($55,715)	($55,715)	($55,715)	($55,715)	($55,715)
(Less) Real Estate Taxes	(4)	($0)	($8,256)	($8,256)	($12,962)	($18,240)
Expense and Taxes: Per Unit		1393	1599	1599	1717	1849
Expense and Taxes: as % of EGI		32%	37%	37%	40%	43%
NET OPERATING INCOME		$107,529	$107,529	$107,529	$102,823	$97,545
(Less) Current Debt Service	(5)	0	(26,574)	(48,433)	(85,778)	(84,819)
BEFORE TAX CASH FLOW		107,529	80,955	59,096	17,045	12,726
1986 Depreciation Deduction	(6)	0	$7,200	$12,000	$55,744	$112,640
1986 Interest Deduction		0	$18,817	$40,808	$77,861	$80,000
TAXABLE INCOME		107,529	$81,512	$54,721	($30,782)	($95,095)
(Less) Tax						
15% Bracket		($16,129)	($12,227)	($8,208)	$4,617	$14,264
22% Bracket		($23,656)	($17,933)	($12,039)	$6,772	$20,921
50% Bracket		($53,764)	($40,756)	($27,360)	$15,391	$47,548
AFTER TAX CASH FLOW						
15% Bracket		$91,399	$69,285	$67,304	($26,164)	($80,831)
22% Bracket		$83,872	$63,579	$42,682	($24,010)	($74,174)
50% Bracket		$53,764	$40,756	$27,360	($15,391)	($47,548)

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.
(2) Vacancy/Bad Debt Allowance is calculated at 6% of residential gross.
(3) Operating Expenses are calculated using the methods described in Section IV.
(4) Real Estate Taxes are 1.14% of 1986 assessed value.
(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.
(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971, 1976 and 1981 to maximize deduction.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	360,000	600,000	1,040,000	1,600,000
Maximum Loan/Value Ratio		80%	80%	80%	80%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$288,000	$480,000	$832,000	$822,700
% of Purchase Price		80%	80%	80%	51%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30 yrs
DEBT SERVICE		($26,574)	($48,433)	($85,778)	($84,819)
Depreciation Method	(5)	40 yrs 125%	40 yrs 125%	15 yrs 175%	19 yrs 175%
Initial Depreciable Basis	(6)	$288,000	$480,000	$832,000	$1,280,000

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(1) Purchase price is calculated by the method described in Section V.

(2) Mortgage amount is calculated as the lesser of an 80% loan-to-value ratio or a 1.15% debt coverage ratio.

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 mortgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE   Prototype T-2

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 13,750 sf					
TOTAL COST: $82,500					
Current Debt Serice	$0	($26,574)	($48,433)	($85,778)	($84,819)
Upgrade Debt Service (1)	($13,083)	($13,083)	($13,083)	($13,083)	($13,083)
Total Debt Service	($13,083)	($39,657)	($61,516)	($98,861)	($97,902)
BEFORE TAX CASH FLOW	$94,446	$67,872	$46,013	$3,962	($357)
AFTER TAX CASH FLOW					
15% Bracket	$79,520	$56,849	$39,008	$9,783	$15,110
22% Bracket	$72,554	$51,704	$35,739	$12,499	$22,329
50% Bracket	$44,692	$31,127	$22,663	$23,364	$51,201
LEVEL 1					
Cost/sf $21					
Building Size: 13,750 sf					
TOTAL COST: $288,750					
Current Debt Service	$0	($26,574)	($48,433)	($85,778)	($84,819)
Upgrade Debt Service (1)	($45,790)	($45,790)	($45,790)	($45,790)	($45,790)
Total Debt Service	($45,790)	($72,364)	($94,223)	($131,568)	($130,609)
BEFORE TAX CASH FLOW	$61,739	$35,165	$13,305	($28,745)	($33,064)
AFTER TAX CASH FLOW					
15% Bracket	$49,821	$27,150	$9,309	($19,916)	($14,589)
22% Bracket	$44,259	$23,409	$7,444	($15,796)	($5,967)
50% Bracket	$22,013	$8,448	($17)	$684	$28,522
LEVEL 2					
Cost/sf $25					
Building Size: 13,750 sf					
TOTAL COST: $343,750					
Current Debt Serice	$0	($26,574)	($48,433)	($85,778)	($84,819)
Upgrade Debt Service (1)	($54,512)	($54,512)	($54,512)	($54,512)	($54,512)
Total Debt Service	($54,512)	($81,086)	($102,945)	($140,290)	($139,331)
BEFORE TAX CASH FLOW	$53,017	$26,443	$4,583	($37,467)	($41,786)
AFTER TAX CASH FLOW					
15% Bracket	$41,901	$19,230	$1,389	($27,836)	($22,508)
22% Bracket	$36,714	$15,864	($101)	($23,341)	($13,512)
50% Bracket	$15,965	$2,400	($6,064)	($5,363)	$22,474

(1) Seismic upgrades assumed to be fully financed with 10-year improvment loan at 10%.

BUILDING T-2

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$82,500	$2,063	$27	$407	7%
LEVEL 1	$21	$288,750	$7,219	$95	$475	25%
LEVEL 2	$25	$343,750	$8,594	$114	$499	30%

BUILDING T-3

With the exception that it is owned and managed by a non-profit organization, the building represented by prototype T-3 is identical to that described by prototype T-2.

Demonstrating practices common to non-profit owners, the rents in this building are lower ($300 per unit) and the operating expenses are higher than for the comparable privately-owned building. Because the demand for inexpensive units is high, this building's vacancy rate is lower than that used in prototype T-2.

Reflecting the lower rents and higher expenses, this buildings's operating expenses, while amounting to $2,000 per unit, consume a substantial portion of the effective gross income.

As in prototype C-3, we have assumed that sixty percent of the purchase price has been covered by grants or deferred-interest loans.

Although the monthly rent increases that would be allowed if this building is reinforced are the same as for building T-2, the presumably very low-income tenants in this nonprofit-owned building will face a larger percentage increase over their current rent.

PROTOTYPE #	T-3
NEIGHBORHOOD	TENDERLOIN
OWNERSHIP	NON-PROFIT
BUILDING TYPE	APARTMENTS NO COMMERCIAL
# STORIES	5 WITH ELEVATOR
TOTAL BUILDING AREA (1)	13,750 SQFT
# RES. UNITS	40 STUDIOS
RESIDENTIAL RENT	$300 /ROOM/MONTH
COMMERCIAL AREA	0 SQFT
COMM. RENT	SQFT/MO

(1) Building area is calculated as follows:

40 studios @ 275 sf = 11000 sf
x 1.25 circulation factor = 13750 sf TOTAL

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE T-3

		(1) NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential		$144,000	$144,000	$144,000	$144,000	$144,000
1986 Gross Income - Commercial		$0	$0	$0	$0	$0
GROSS POSSIBLE INCOME		$144,000	$144,000	$144,000	$144,000	$144,000
(Less) Vacancy/Bad Debt	(2)	($7,200)	($7,200)	($7,200)	($7,200)	($4,300)
EFFECTIVE GROSS INCOME		$136,800	$136,800	$136,800	$136,800	$136,800
(Less) Operating Expenses	(3)	($59,028)	($59,028)	($59,028)	($59,028)	($59,028)
(Less) Real Estate Taxes	(4)	($8,256)	($8,256)	($8,256)	($12,962)	($18,240)
Expenses and Taxes: Per Unit		1682	1682	1682	1800	1932
Expenses and Taxes: as % of EGI		49%	49%	49%	53%	56%
NET OPERATING INCOME		$69,516	$69,516	$69,516	$64,810	$59,532
(Less) Current Debt Service	(5)	0	(13,287)	(24,217)	(42,889)	(51,766)
BEFORE TAX CASH FLOW		69,516	56,229	45,299	21,921	7,766
1986 Depreciation Deduction	(6)	0	$7,200	$12,000	$58,240	$170,240
1986 Interest Deduction		0	$9,409	$20,404	$38,931	$48,825
TAXABLE INCOME	(7)	69,516	$52,907	$37,112	($32,361)	($159,533)
(Less) Tax						
15% Bracket		($10,427)	($7,936)	($5,567)	$4,854	$23,930
22% Bracket		($15,293)	($11,640)	($8,165)	$7,119	$35,097
50% Bracket		($34,758)	($26,453)	($18,556)	$16,180	$79,767
AFTER TAX CASH FLOW						
15% Bracket		$59,088	$48,293	$39,732	$26,775	$31,696
22% Bracket		$54,222	$44,589	$37,135	$29,041	$42,863
50% Bracket		$34,758	$29,776	$26,743	$38,102	$87,533

---

(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.

(2) Vacancy/Bad Debt Allowance is calculated at 5% of residential gross.

(3) Operating Expenses are calculated using the methods described in Section IV.

(4) Real Estate Taxes are 1.14% of 1986 assessed value.

(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.

(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased in 1971, 1976, and 1981 to maximize deduction.

(7) Tax deductions are shown to demonstrate tax benefits passed through to limited partners if non-profit owner syndicates property.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	360,000	600,000	1,040,000	1,600,000
Maximum Loan/Value Ratio		40%	40%	40%	40%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$144,000	$240,000	$416,000	$502,100
Actual Loan/Value Ratio		40%	40%	40%	31%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30
DEBT SERVICE		($13,287)	($24,217)	($42,889)	($51,766)
Depreciation Method	(5)	40 yrs	40 yrs	15 yrs	19 yrs
Acceleration (if applicable)		125%	125%	175%	175%
Initial Depreciable Basis	(6)	$288,000	$480,000	$832,000	$1,280,000

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(1) Purchase price is calculated by the method described in Section V.

(2) Mortgage amount is calculated as 40% of the purchase price. Non-Profit owner is assumed to receive subsid for remainder of purchase price.

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 motgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE   Prototype T-3

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 13,750 sf					
TOTAL COST: $82,500					
Current Debt Serice	$0	($13,287)	($24,217)	($42,889)	($51,766)
Upgrade Debt Service (1)	($13,083)	($13,083)	($13,083)	($13,083)	($13,083)
Total Debt Service	($13,083)	($26,370)	($37,300)	($55,972)	($64,849)
BEFORE TAX CASH FLOW	$56,433	$43,146	$32,216	$8,838	($5,317)
AFTER TAX CASH FLOW					
15% Bracket	$47,209	$36,413	$27,853	$14,896	$19,817
22% Bracket	$42,904	$33,271	$25,817	$17,723	$31,545
50% Bracket	$25,686	$20,704	$17,671	$29,030	$78,461
LEVEL 1					
Cost/sf $16					
Building Size: 13,750 sf					
TOTAL COST: $220,000					
Current Debt Service	$0	($13,287)	($24,217)	($42,889)	($51,766)
Upgrade Debt Service (1)	($34,888)	($34,888)	($34,888)	($34,888)	($34,888)
Total Debt Service	($34,888)	($48,175)	($59,104)	($77,777)	($86,654)
BEFORE TAX CASH FLOW	$34,628	$21,341	$10,411	($12,966)	($27,122)
AFTER TAX CASH FLOW					
15% Bracket	$27,410	$16,614	$8,054	($4,903)	$17
22% Bracket	$24,041	$14,408	$6,953	($1,141)	$12,682
50% Bracket	$10,567	$5,584	$2,552	$13,910	$63,341
LEVEL 2					
Cost/sf $21					
Building Size: 13,750 sf					
TOTAL COST: $288,750					
Current Debt Serice	$0	($13,287)	($24,217)	($42,889)	($51,766)
Upgrade Debt Service (1)	($45,790)	($45,790)	($45,790)	($45,790)	($45,790)
Total Debt Service	($45,790)	($59,077)	($70,007)	($88,679)	($97,556)
BEFORE TAX CASH FLOW	$23,726	$10,439	($491)	($23,869)	($38,024)
AFTER TAX CASH FLOW					
15% Bracket	$17,510	$6,714	($1,846)	($14,803)	($9,883)
22% Bracket	$14,609	$4,976	($2,479)	($10,573)	$3,250
50% Bracket	$3,006	($1,976)	($5,008)	$6,350	$55,781

(1) Seismic upgrades financed with 10-year improvment loan at 10%.

BUILDING T-3

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$82,500	$2,063	$27	$327	9%
LEVEL 1	$21	$288,750	$7,219	$95	$395	32%
LEVEL 2	$25	$343,750	$8,594	$114	$414	38%

BUILDING B-1

Prototype B-1 represents a four story Bush Street apartment building. The building has 20 studio apartments that rent at an average of $420 per month, and 15 one-bedroom units whose rents average $520. Reflecting the fact that this neighborhood has less turnover than the Tenderloin, the vacancy/collection loss rate for this building is 4%.

This prototype reflects a typical unreinforced masonry building located in the Bush Street corridor. Seventy-three percent of the URM residential buildings in this area are apartment buildings. One-third of these are four stories tall, and 35% of the Bush Street apartment buildings have twenty to thirty-five units.

Purchase prices for buildings in this located in the last few years appear to be somewhat too high for the current rents to support. If the estimated sales prices are correct, owners may be paying higher prices at the present time with the expectation that rents will rise substantially in the near future.

PROTOTYPE #	B-1	
NEIGHBORHOOD	BUSH STREET	
OWNERSHIP	PRIVATE	
BUILDING TYPE	APARTMENTS NO COMMERCIAL	
# STORIES	4	NO ELEVATOR
TOTAL BUILDING AREA (1)	13,438	SQFT
# RES. UNITS	20 15	STUDIOS 1-BEDROOMS
RESIDENTIAL RENT	$420 $520	/STUDIO/MONTH /1-BR/MONTH
COMMERCIAL AREA	0	SQFT
COMM. RENT		SQFT/MO

(1) Building area is calculated as follows:

20 studios @ 275 sf and 15 1BR @ 350 sf = 10750 sf
x 1.25 circulation factor = 13438 sf TOTAL

1986 FINANCIAL PRO FORMA BY YEAR OF PURCHASE: PROTOTYPE B-1

	NO MORTGAGE (1)	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
1986 Gross Income - Residential	$194,400	$194,400	$194,400	$194,400	$194,400
1986 Gross Income - Commercial	$0	$0	$0	$0	$0
GROSS POSSIBLE INCOME	$194,400	$194,400	$194,400	$194,400	$194,400
(Less) Vacancy/Bad Debt (2)	($7,800)	($7,800)	($7,800)	($7,800)	($7,800)
EFFECTIVE GROSS INCOME	$186,600	$186,600	$186,600	$186,600	$186,600
(Less) Operating Expenses (3)	($50,081)	($50,081)	($50,081)	($50,081)	($50,081)
(Less) Real Estate Taxes (4)	($6,743)	($6,743)	($6,743)	($13,522)	($17,955)
Expenses and Taxes: Per Unit	1624	1624	1624	1817	1944
Expenses and Taxes: as % of EGI	30%	30%	30%	34%	36%
NET OPERATING INCOME	$129,776	$129,776	$129,776	$122,997	$118,564
(Less) Current Debt Service (5)	0	(28,419)	(39,554)	(89,490)	(103,099)
BEFORE TAX CASH FLOW	129,776	101,357	90,223	33,507	15,465
1986 Depreciation Deduction (6)	0	$7,700	$9,800	$58,156	$110,880
1986 Interest Deduction	0	$20,124	$33,327	$81,230	$97,243
TAXABLE INCOME	129,776	$101,952	$86,649	($16,389)	($89,559)
(Less) Tax					
15% Bracket	($19,466)	($15,293)	($12,997)	$2,458	$13,434
22% Bracket	($28,551)	($22,430)	($19,063)	$3,606	$19,703
50% Bracket	($64,888)	($50,976)	($43,325)	$8,195	$44,780
AFTER TAX CASH FLOW					
15% Bracket	$110,310	$86,065	$77,225	$35,965	$28,899
22% Bracket	$101,226	$78,928	$71,160	$37,113	$35,168
50% Bracket	$64,888	$50,381	$46,898	$41,702	$60,245

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(1) This column represents a building under long-term ownership with the mortgage fully repaid and all depreciation taken.

(2) Vacancy/Bad Debt Allowance is calculated at 4% of residential gross.

(3) Operating Expenses are calculated using the methods described in Section IV.

(4) Real Estate Taxes are 1.14% of 1986 assessed value.

(5) Debt Service is calculated based on mortgage terms in the year purchased as explained in Section V.

(6) Depreciation deduction reflects a switch from accelerated to straight line method for buildings purchased 1976, and 1981 to maximize deduction.

MORTGAGE AND DEPRECIATION CALCULATION

		1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
TOTAL PURCHASE PRICE	(1)	$385,000	$490,000	$1,085,000	$1,575,000
Maximum Loan/Value Ratio		80%	80%	80%	80%
Minimum Debt Coverage Ratio		1.15	1.15	1.15	1.15
MORTGAGE AMOUNT	(2)	$308,000	$392,000	$868,000	$1,000,000
% of Purchase Price		80%	80%	80%	63%
Interest Rate	(3)	8.50%	9.50%	9.75%	9.75%
Amortization Period	(4)	30 yrs	30 yrs	30 yrs	30 yrs
DEBT SERVICE		($28,419)	($39,554)	($89,490)	($103,099)
Depreciation Method	(5)	40 yrs	40 yrs	15 yrs	19 yrs
Acceleration (if applicable)		125%	125%	175%	175%
Initial Depreciable Basis	(6)	$308,000	$392,000	$868,000	$1,260,000

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(1) Purchase price is calculated by the method described in Section V.

(2) Mortgage amount is calculated as the lesser of an 80% loan-to-value ratio or a 1.15% debt coverage ratio.

(3) Rates for 1981 and 1986 mortgages are variable. Current debt service is calculated at 1986 rates.

(4) 1981 and 1986 motgages are 15-year loans with a 30-year amortization schedule.

(5) Depreciation is calculated according to the method effect in the year of purchase.

(6) Depreciable basis calculation assumes building value is 80% of total building cost.

CASH FLOW BY UPGRADE OPTION AND MORTGAGE DATE Prototype B-1

UPGRADE OPTION	NO MORTGAGE	1971 PURCHASE	1976 PURCHASE	1981 PURCHASE	1986 PURCHASE
WALL ANCHORAGE					
Cost/sf $6					
Building Size: 13,438 sf					
TOTAL COST: $80,628					
Current Debt Serice	$0	($28,419)	($39,554)	($89,490)	($103,099)
Upgrade Debt Service (1)	($12,786)	($12,786)	($12,786)	($12,786)	($12,786)
Total Debt Service	($12,786)	($41,205)	($52,340)	($102,276)	($115,885)
BEFORE TAX CASH FLOW	$116,990	$88,571	$77,437	$20,721	$2,679
AFTER TAX CASH FLOW					
15% Bracket	$98,695	$74,449	$65,610	$24,350	$17,284
22% Bracket	$90,157	$67,859	$60,091	$26,044	$24,099
50% Bracket	$56,005	$41,498	$38,014	$32,818	$51,361
LEVEL 1					
Cost/sf $16					
Building Size: 13,438 sf					
TOTAL COST: $215,008					
Current Debt Service	$0	($28,419)	($39,554)	($89,490)	($103,099)
Upgrade Debt Service (1)	($34,096)	($34,096)	($34,096)	($34,096)	($34,096)
Total Debt Service	($34,096)	($62,515)	($73,650)	($123,586)	($137,195)
BEFORE TAX CASH FLOW	$95,680	$67,261	$56,127	($589)	($18,631)
AFTER TAX CASH FLOW					
15% Bracket	$79,350	$55,104	$46,265	$5,005	($2,061)
22% Bracket	$71,729	$49,431	$41,663	$7,616	$5,672
50% Bracket	$41,246	$26,739	$23,255	$18,059	$36,602
LEVEL 2					
Cost/sf $21					
Building Size: 13,438 sf					
TOTAL COST: $282,198					
Current Debt Serice	$0	($28,419)	($39,554)	($89,490)	($103,099)
Upgrade Debt Service (1)	($44,751)	($44,751)	($44,751)	($44,751)	($44,751)
Total Debt Service	($44,751)	($73,170)	($84,305)	($134,241)	($147,850)
BEFORE TAX CASH FLOW	$85,025	$56,606	$45,471	($11,244)	($29,286)
AFTER TAX CASH FLOW					
15% Bracket	$69,675	$45,429	$36,590	($4,670)	($11,736)
22% Bracket	$62,511	$40,213	$32,445	($1,602)	($3,546)
50% Bracket	$33,857	$19,350	$15,867	$10,671	$29,214

(1) Seismic upgrades assumed to be fully financed with 10-year improvement loan at 10%.

BUILDING B-1

IMPACT OF SEISMIC UPGRADING ON CURRENT RENTS

UPGRADE LEVEL	COST PER SQFT	TOTAL COST	COST PER UNIT	MONTHLY RENT INCREASE PER UNIT	NEW RENT	PERCENT INCREASE OVER CURRENT RENTS
WALL ANCHORAGE	$6	$80,628	$2,304	$30	$425-520	6-8%
LEVEL 1	$16	$215,008	$6,143	$81	$471-576	16-21%
LEVEL 2	$21	$282,198	$8,063	$107	$502-602	22-27%

CONCLUSIONS

The economic pro formas developed here approximate typical financial conditions for owners of URM buildings in Chinatown, the Tenderloin, and the Bush Street Corridor.

From the pro formas, we can see that buildings that have been held for some time do maintain positive cash flows despite low residential rents. This is because debt service costs are low. Many buildings purchased recently, however, are barely breaking even or show a negative before tax cash flow when financed conventionally. The point is, most buildings that have sold within the last five years are not economic. Sales prices are significantly higher than their rental incomes can support.

This is particularly true for buildings in the Tenderloin and Bush Street neighborhoods where there have been as many as twelve sales per year. While it may be true that sale prices are higher than economic values in Chinatown as well, there have only been three URM building sales in this neighborhood in the last five years, so an average market value is difficult to predict.

Only buildings which been held by the same owner for ten to fifteen years have strong positive before-tax cash flows. It may seem that these owners could support the additional cost of a seismic upgrading, but long term owners typically are not real estate developers. In most cases, they are the "mom and pop" owners of a single building, and the building may be their main source of income. (Based on available city data, it is not possible to distinguish individual owners from management firms or investment companies. National statistics tell us however that 60% of inner city residential buildings are owned by "mom and pops".) What this means is that even though cash flows may indicate an ability to assume some additional debt, individual owners may not be able to afford the upgrading. Further, because the economic values of the buildings are low, these owners would not qualify for bank loans for building improvements, especially for non-cosmetic rehabilitation.

If owners with positive cash flows have trouble with private financing, clearly the buildings which are barely breaking even will not be looked on favorably by lenders. From the tables on the impact of upgrading on cash-flow, it is evident that the cost of a wall anchorage system is within the realm of the possible while Levels 1 and 2 are substantially greater than most owners could afford or be able to finance.

The per square foot cost of these methods of upgrading translate into average per unit costs of approximately $1,000 for wall anchors, $5-$7,000 for Levels 1 and 2, and $12-$15,000, if additional code violations are corrected and cosmetic renovation is undertaken at the same time.[5] In terms of the overall economic impact on the city, this implies:

minimal upgrading	$1000 x 26,000 apt. and hotel units = $26,000,000.
full code	$5-7000 x 26,000 units = $130-182,000,000.
total rehab	$12-14000 x 26,000 units = $312-390,000,000.

Similarly the impact on tenants is substantial. For every $1000 in rehabilitation costs the owner is allowed to pass through a rent increase of $13.22 per month. With an upgrading cost of $7000, the rent increase is $92.51; for $15,000, the increase is $198.23. This represents a 50 to 100% increase in rent for tenants who are, for the most part low-income and elderly.

These figures represent general financial conditions in Chinatown, the Tenderloin, and the Bush Street Corridor. They indicate that any cost above the level of a minimal upgrade would prove difficult for building owners to absorb, nearly impossible to finance, and a severe hardship on existing tenants.

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[5] Estimates close to the $15,000 end of this range include more than seismic upgrading. Also included are improvements that a bank would require in order to make a loan.

CHAPTER III. SEISMIC STRENGTHENING AND ASSOCIATED COSTS

EARTHQUAKE ENGINEERING

There are several disciplines involved in the general field of the earthquake engineering. The disciplines have focused primarily on two issues: 1.) the environmental causes and effects of seismic events and 2.) how buildings perform when exposed to such events. The first topic has been addressed by geotechnical engineers and earth scientists. The second topic has been addressed mainly by civil and structural engineers and architects. The primary research methodologies employed have been reconnaissance reports from field investigations after major disasters;experimental data from research on the strength of building materials, structural systems, etc; and engineering analytical models for structural analysis. Knowledge has been primarily focused on new building design, although in the last decade a good deal of attention has been focused on existing buildings.

New design considerations and their adoption into the building code are the major concerns of earthquake engineering literature on new construction. Experimental research addressing new building component and system types has been done on the force deformation characteristics of structural components for new buildings. Post-earthquake evaluations of buildings and analytical models advance the development of earthquake resistant design technologies. Recently, the Federal Emergency Management Agency (FEMA) initiated an attempt to consolidate this information and put it into a usable and valuable form as seismic regulations for buildings. Many groups were involved including National Science Foundation (NSF), Applied Technology Council (ATC), Structural Engineers Association of California (SEAOC), National Bureau of Standards (NBS),American Society of Civil Engineers (ASCE), National Institute of Building Sciences(NIBS), and Building Seismic Safety Council (BSSC.)The bulk of this work involved the Tentative Provisions for the Development of Seismic Regulations for Buildings, done by ATC in 1978 and later analyzed by BSSC. The objectives of this set of provisions are:

1. To evaluate the knowledge acquired in recent research and experience gained during on-site observations of the effects of earthquakes and to assemble it in a concise and comprehensive document for general use by building design professionals and others.

2. To write the tentative design provisions so as to permit, insofar as possible, ingenuity of solution, but with definitive criteria to evaluate the resulting design.

3. To provide seismic protection criteria which will be applicable to all probable earthquake areas of the United States.

4. To recognize that acceptable seismic risk is a matter of public policy determined by a specific government body and should be based upon:
    (a)An evaluation of available technical knowl-edge, including the areas of seismicity.

(b)Reasonable means available for protection.

(c)The magnitude of the earthquake risk compared with acceptable risks for other hazards.

(d)The economic and social impact of a major catastrophe.

5. To provide tentative design provisions applicable to all buildings, including existing buildings, and appropriate structural as well as nonstructural components. To include requirements for structural analysis, design, and detailing which will provide adequate earthquake resistance for typical buildings and to make recommendations with respect to the design of atypical buildings.

6. To recognize that for critical facilities there should be consideration in the design of building structural and nonstructural systems of limiting damage in order to maintain the level of function determined to be necessary.

7. To provide a commentary to assist the user in understanding the intent and background of the provisions and to assess the implications of any alterations made to the provisions in the future.[1]

Work is still in progress on seismic code development,reflecting state-of-the-art knowledge of earthquake resistant design in new buildings.

Seismic Retrofit of Existing Buildings

The work on existing buildings began relatively recently. With the recognition that our present seismic hazard exists not in buildings currently being designed, but in our stock of existing buildings, and that the primary solution to this problem rested in large part in the technical domain of engineers, FEMA held a workshop on "Reducing SeismicHazards of Existing Buildings" in December, 1985. The workshop was put together by ATC, BSSC and EERI (Earthquake Engineering Research Institute), with the intent of clarifying state-of-the-art information regarding the methodologies for evaluating seismically hazardous buildings and procedures for strengthening existing buildings.

The first step in reducing the seismic hazards associated with existing buildings is identification of potentially hazardous buildings. While several such models exist,there is a consensus on the overall methodology. Generally this consists of identification of categories of potentially hazardous buildings by preparing a building inventory database. The potential hazard of an existing building can be valuated in several different terms, including life loss and injuries, cost of repairs and reconstruction, social and economic losses, and physical damage to the building. While the assessment of potential hazard is relatively straightforward, the evaluation of the seismic performance of specific buildings is more problematic. It is generally agreed that unreinforced masonry (URM) buildings are the most potentially vulnerable type of building in terms of physical damage and these have been the focus of most buildings surveys. (See Figure 5.)

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[1] Applied Technology Council, Tentative Provisions for the Development of Seismic Regulations for Buildings and Proposed Amendments, 1982, pp 2-3.

Despite recent advances in structural analysis and in correlation between earthquake characteristics and structural response, prediction of damage in individual buildings is still subject of much uncertainty. An accurate assessment of performance must be based on experience and observation of performance in previous earthquakes and on the structural uniqueness of specific buildings. In the 1985 FEMA"Workshop on Reducing Seismic Hazards of Existing Buildings,"Boris Bresler described the work necessary to establish an acceptable level of seismic performance on some probabilistic or acceptable risk basis. According to Bresler, while work has been done, there is

> no sufficient data base to verify the validity of the methods used for risk assessment, and establishment of an acceptable level of seismic risk is a socio-economic decision arrived at through a political process. However, to the extent that such a decision must take into account technological factors, it is appropriate to review the proposed values of the reduced level of seismic performance of old buildings as compared to that of buildings designed in accordance with current building codes. This approach is acceptable with respect to the increased risk of property damage; it is not acceptable with respect to increased risk of life loss or injury.

While there is much uncertainty associated with the seismic performance of a specific building, some general consensus exists in the engineering community on certain issues regarding unreinforced masonry (URM) buildings. There is general agreement on the fact that URM buildings pose a serious threat to life safety. Also there is agreement on the typical collapse mechanisms and the basic steps and strengthening requirements common to almost all URM buildings. While the exact method of strengthening will vary according to building characteristics and preferences of individual engineers, these variations fall within a relatively small range.

Over the last several years, techniques have been developed for the retrofit and strengthening of existing buildings. Some of these techniques have been analyzed experimentally and proven through experience in actual earthquakes. The system of wall anchors, shear bolts and ties is one such example. More recent and innovative developments, though, do not have the benefit of a post-earthquake performance record. Thus, for methods such as steel bracing, while some analytical substantiation of its validity has occurred, there remain many associated uncertainties.

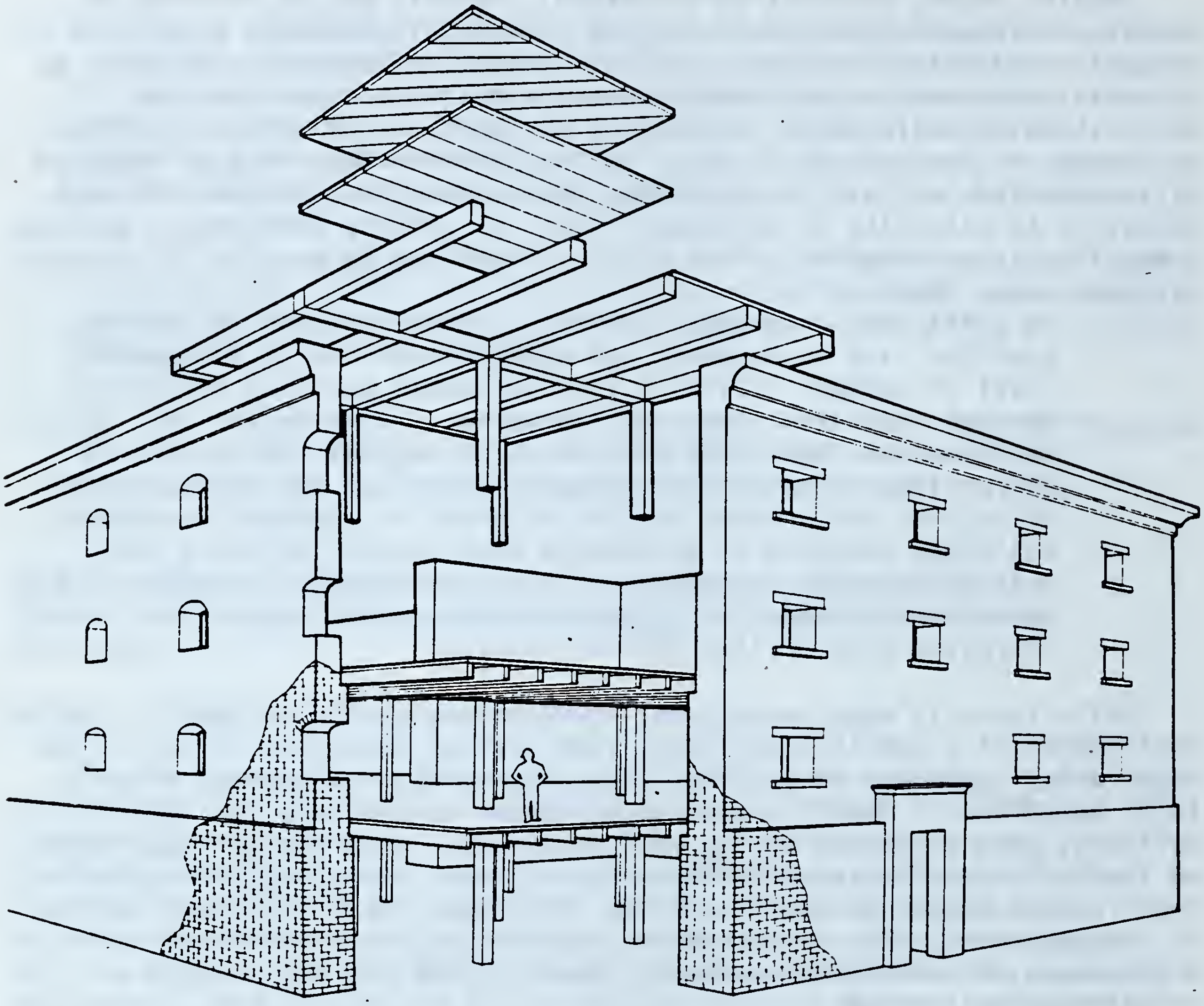
Recently much effort has been expended studying the retrofit of existing buildings. Still, specific criteria for strengthening have not yet been accepted by the larger engineering community. Similarly, many municipalities have implemented retroactive building codes, but a comprehensive code specific to existing buildings has yet to be established. This is due in part to the fact that the premises of earthquake resistant design are extremely broad, especially in the case

Roof/floor span system

1. wood post and beam (heavy tinber)
2. wood post, beam, and joist (mill construction)
3. wood truss - pitch and curve

Roof/floor diaphragms

4. diagonal sheathing
5. straight sheathing



Details

6. typical unbraced parapet and cornice
7. flat arch window openings
8. small window penetrations
   (if bldg. is orginally a warehouse)

9. bearing wall - 4 to 8 wythes of brick

Figure 5
Unreinforced Masonry Bearing Wall Buildings - 3 and 4 Stories

Source: Lagorio, Henry J., Howard Friedman and Kit Wong, Issues for Seismic Strengthening of Existing Buildings: A Practical Guide for Architects, Center for Environmental Design Research, University of California, Berkeley.

of existing buildings. Such factors as age,materials, workmanship, etc., must be incorporated into the engineering designs. Thus, mathematical models alone cannot define the problems and/or regulate solutions. In-stead engineering judgment must be included in the process. Further, all the existing municipal codes acknowledge that,due to economic factors, strengthening criteria cannot be based on current code requirements, but instead must be based on provision of an acceptable level of life safety. The definition of this level of safety, though, is not solely in the domain of the engineering community, but the political community as well. Clearly, the establishment of an acceptable set of strengthening criteria for existing buildings is a complex task.

Seismic Codes for Existing Buildings

To date, the implementation of seismic upgrading requirements specific to existing buildings has been a local activity, while the state's role has been primarily one of encouraging these local policies. However, in September of 1986 the International Conference of Building Officials(ICBO) adopted the Uniform Code for Building Conservation(UCBC). This includes a section on seismic upgrading of hazardous buildings which applies to all URM bearing wall structures constructed prior to the adoption of earthquake design requirements by the jurisdiction. If California chooses to adopt this code, it would give further credibility to California's recently adopted State Historic Building Code.[2]

Several municipalities in California have established seismic codes specific to existing buildings. (See Figure 6.) These ordinances are in part a response to legislation(S.B.445) sponsored by the California Seismic Safety Commission (SSC) in 1979 which allows local governments to develop retroactive seismic codes that would be less stringent than current code requirements for new buildings. This removes a potential liability barrier to the adoption of such ordinances. In 1984, the SSC sponsored legislation (S.B.1797) which would have required local governments to identify hazardous buildings in their jurisdiction, notify owners, and urge these owners to make their buildings safer. This legislation was passed by the legislature but vetoed by the Administration. In July 1986, a similar but less comprehensive bill (S.B.547) became law, requiring all local governments to identify potentially hazardous URM buildings, notify owners,and prepare a program for mitigation of the identified potentially hazardous buildings.

The local ordinances established thus far are of two types, active and passive (Holmes and Thurston, 1985 Active abatement targets specific buildings, classes of buildings, or elements of buildings and requires specified actions to be taken. Passive abatement programs require hazard

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[2] The California State Historic Building Code is in its early stages of implementation. This code leaves the seismic requirements to the discretion of the Building Official. It effectively allows arbitration between local and state officials in requirements related to seismic forces.

COMPARISON ISSUE	SANTA ROSA	LOS ANGELES	SANTA ANA	LONG BEACH
Date program became effective	October 1971	January 1980	February 1980	January 1977
Code basis for lateral forces	1955 UBC	Hybrid - perhaps greater than 1984 UBC	Same as Los Angeles	1970 UBC (1979 originally)
Time frame of rehabilitation	One year from date of notification (approximately one builidng per week continuous noticing process. Possible completion by 1990.	Obtain permit withing one year, commence construction withing 8 months, complete within 3 years of notifcation. Time extions of up to 7 years for wall anchoring system installation.	Same as Los Angeles, except time extension 5 years maximum.	Three phases: One year from 1978 for excessive hazard. Three years from 1984 for high hazard. Five years from 1991 for immediate hazard.
Total number of buildings	750 in first two risk categories	7,800	200	800
Building type size or age criteria	Assembly and office retail or restaurant buildings over 100 occupants initially), apartments and other low occupany building (later). Constructed prior to 1959 except one and two family. Includes parapets.	All unreinforced masonry building constructed prior to 1934 except single family or apartments with less than five units. Parapets under previous ordinance.	All unreinforced masonry with less than 50% of the steel reinforcing required by 1979 UBC except single family or apartments with less than five units. Parapets included.	All occupancies, largely unreinforced masonry with four or more stories except single family. Parapets included.
Risk Categories	7	4	4	3
Risk/hazard assessment criteria or schedule	Priority of review established by occupancy class and occupant load.	Based on occupancy class and primarily occupant load based on UBC TAble 33-1.	Same as Los Angeles	Based on occupancy class and load, severity of structural deficiencies. Phases by occupant class and height
Structural deficiency rating criteria	1955 UBC	Calculation of the building's lateral force resistance based on Los Angeles code sysatm.	Same as Los Angeles	Ratio of lateral force capacity of the building to the required capacity based on 1970 UBC levels.
Appeals process	none	Board of Building Safety Commissioners for time extensions.	Uniform Code Appeals Broad.	Staff level for up to 120-day extension; Board of Examiner, Appeals and Condemnation for demolition order only.
Potential for vacation or demolition order from city.	Yes	Yes	Yes, using UBC Hazardous Building Code	Yes
Built-in time extension	None	Yes, for anchorage of roof and floors to exterior walls.	Same as Los Angeles	None

Source: Jim Russell

Figure 8
Earthquake Code Comparisons

reduction only when a predefined action (normally involving a change in existing conditions, such as a major renovation and/or change in use) is taken by the owner.

In general, the system of active abatement codes is as follows. First, a target is identified, which may be a class of buildings (e.g. all unreinforced masonry buildings built before 1933), or an element of a building (e.g. parapets). Second, priorities for hazard reduction are determined,generally based on occupancy and use. Third, strengthening requirements are established, designating appropriate force resistance of the building and/or its components and based upon certain assumptions regarding the existing building's strength. And last, a time frame is developed for compliance with the code.

Passive abatement of existing hazardous buildings usually works through a mechanism in which substantial remodeling or additions "trigger" seismic upgrading requirements. "Substantial" remodeling generally includes increases in occupancy load or hazard classification, alterations to the structural system, or alterations which affect a given percentage of the area or value of the building.

Until 1979 the UBC included a passive abatement clause in Section 104: Applications to Existing Buildings. The triggers included: 1.) alterations and/or repairs in excess of 50% of the value of the existing building within a 12month period; 2.) existing use or occupancy changed to a use or occupancy which would not be permitted in a similar new building; and/or 3.) 25% of the roof replaced in any period of 12 months. In addition, the Building Inspector had discretion in every alteration or repair to any structural part or portion of a building to require said work to conform to the code.

Since the 1979 deletion of the "25-50%" rule, the UBC has had no explicit seismic design requirements for the upgrade of existing buildings. The Uniform Code for Building Conservation, adopted by the International Conference of Building Officials in 1986, contains such a clause; however,as mentioned previously, this code has not been adopted by the State of California.

With the ongoing development of earthquake codes, the primary regulatory group is Applied Technology Council (ATC),an independent, nonprofit, tax-exempt corporation established in 1971 through the efforts of the Structural Engineers Association of California. In 1974 ATC was funded by the National Science Foundation and the National Bureau of Standards to conduct a study which would lead in 1978 to the publication of ATC 3-06:Tentative Provisions for this Development of Seismic Regulations for Buildings. This document contains tentative seismic design provisions for use in the development of seismic code regulations for design and construction of buildings. This document and its 1982amendments represent a design philosophy and set of objectives generally accepted by California's structural engineering community. The provisions and principals developed in ATC 3-06 are intended provide a basis for development of seismic design regulations which should enable most buildings to:

1. Resist minor earthquakes without damage.
2. Resist moderate earthquakes without significant structural damage, but with some nonstructural damage.
3. Resist major or severe earthquakes without major failure of the structural framework of the building or its component members and equipment, and to maintain life safety. It is also recognized that for certain critical facilities, particularly those essential to the public safety and well being in case of emergency, criteria should be available to the designer which will permit design of a facility which will remain operational during and after an earthquake.

> It is recognized, however, that because of the random and unpredictable nature of earthquake motions and the uncertainties concerning ultimate strength capacities and the response of buildings to earthquake motions, the seismic design requirements can not fully ensure that there will be no injury or loss of life.[3]

To achieve these goals, ATC 3-06 proposes to place each building in a Seismic Performance Category, assigning it, in effect, a specified degree of protection to be provided for the public and building occupants against the hazards resulting from the effects of earthquake motions in buildings. The bases for this classification are the Seismicity Index (expected ground shaking) and Seismic Hazard Exposure Group (use and occupancy).

In sum, the ATC 3-06 philosophy is to minimize hazards to life. The formula through which it works is based on the probability of maximum ground shaking (or a "design earthquake") and the importance and occupancy of a building. There is no specific formula that relates the ability of a building to withstand a given lateral force to the number of lives potentially saved. Instead, the design provisions attempt to achieve a high degree of life safety through sound design practices which in turn are related probabilistically to site seismicity and building occupancy.

For existing buildings, ATC 3-06 suggests an analysis of seismic resistance based on an "Earthquake Capacity Ratio," which compares the ability of the existing building to resist the effects of earthquake motions to the required capacity for new buildings. Minimum acceptable ratios are assigned in relation to the Seismic Performance Category (described above.)

ATC addresses the issue of life safety in existing hazardous buildings by defining and requiring an acceptable level of force resistance in a new building, and then stating that an existing building must have at least some specified percentage of that strength. The assumption is that the implementation of these requirements will achieve the goal of minimizing the hazard to life.

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[3] Applied Technology Council, Tentative Provisions for the Development of Seismic Regulations for Buildings, and Proposed Amendments, 1982.

There is no direct correlation between the magnitude of a quake and the ability of a building to resist the associated seismic forces. The magnitude is a measure of the earthquake size which describes the amount of energy released. The resulting ground shaking, which causes the actual forces that a building must resist, is affected by the following variables.

1. Location and depth of focus, which affect the amount of energy that reaches the earth's surface at a given location;
2. Length of fault break, which affects the magnitude and duration;
3. Period of quake, with short period ground motions tending to die out more rapidly with distance than do longer period motions, coinciding with the natural period of vibration of low-rise buildings while long period vibrations tend to coincide with longer natural periods of vibrations of tall structures, causing resonances; and
4. Local soil conditions, which affect the ground shaking, the total effect depending upon the type of material in each stratum of the ground, the depth of each type, and the total depth of bedrock.

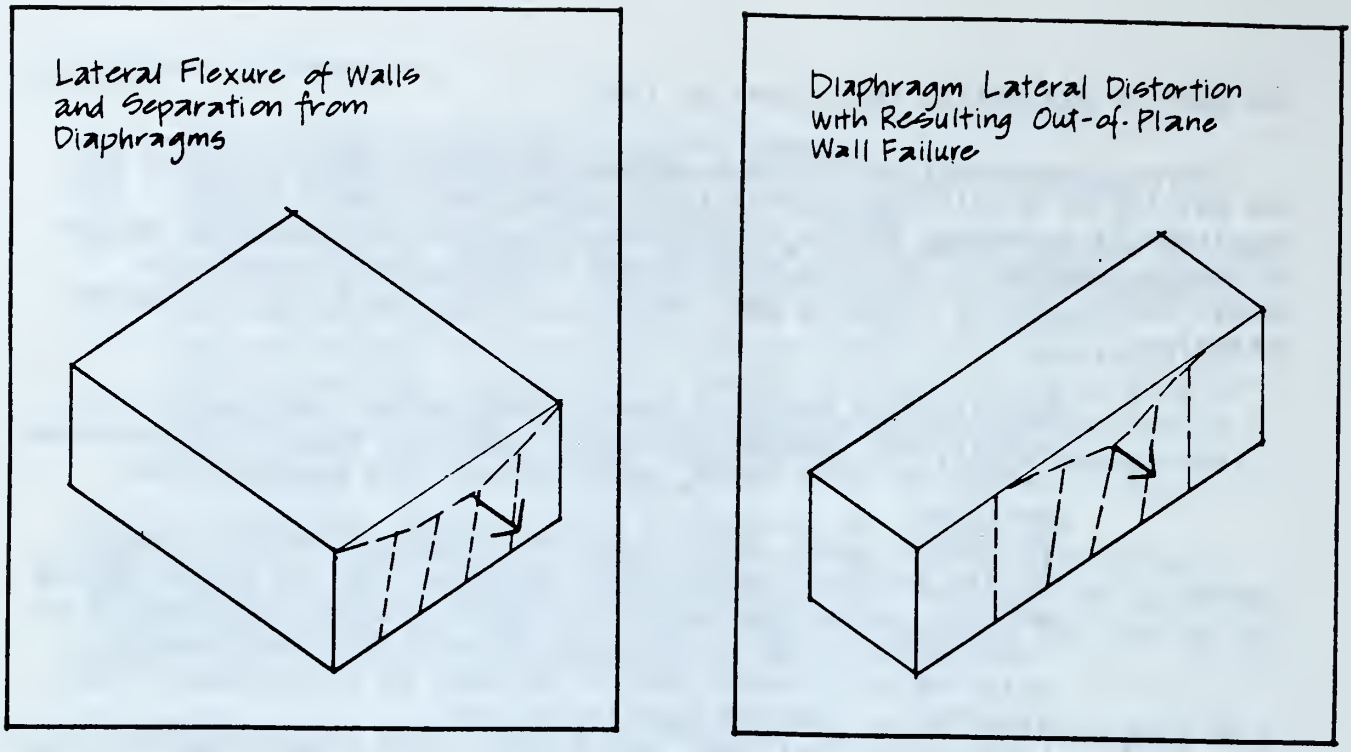
Thus building codes do not equate lateral force requirements to an earthquake of a specific magnitude. Nor do engineers upgrade a building based solely on this criterion. Instead, engineers locate collapse mechanisms of a given building and aim to correct them. Typically, in addition to lack of wall-diaphragm continuity, the major vulnerable features of an URM building are:

1. Torsional Problems - this includes corner buildings with two open facades or buildings with one very open facade when other walls are solid, as well as buildings with irregular configurations.

2. Vertical Discontinuity - this includes buildings with an open first floor (soft story.) Some URM residential buildings have commercial first floors that tend to have large windows and no interior partition walls, creating a discontinuity for shear transfer from the above floors.

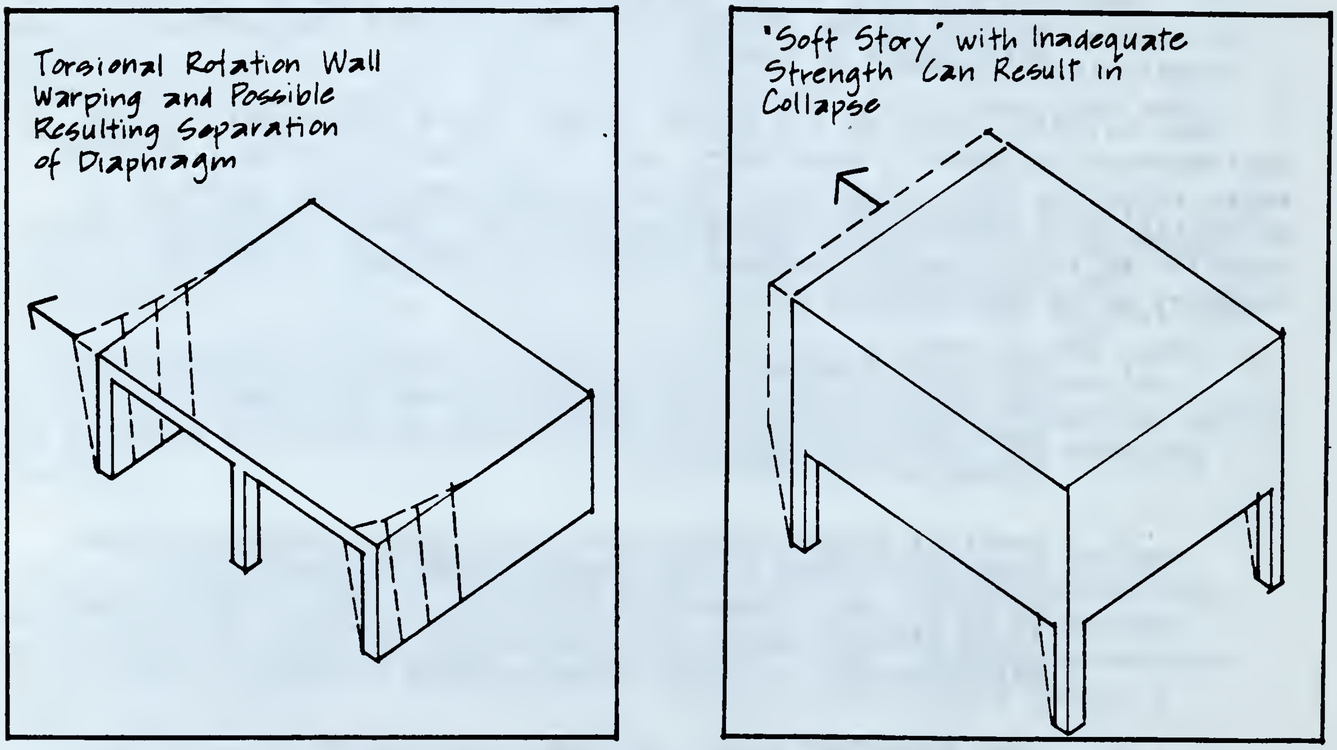
3. Long Diaphragm Span - In long narrow buildings, masonry walls that can serve as shear walls may be far apart. This creates a high shear stress in the floor diaphragms. (See Figure 7.)

To date, most seismic upgrades of unreinforced masonry have been done on large commercial buildings, while very few have been done on small residential buildings. Typically, a system of anchorage, bolts and ties are added at floor-to-wall and roof-to-wall connections; parapets, cornices and other falling hazards are tied to the building; floor and roof diaphragms are reinforced; and shear resisting elements such as


Lateral Flexure of Walls and Separation from Diaphragms
Diaphragm Lateral Distortion With Resulting Out-of-Plane Wall Failure

Lack of Wall-Diaphragm Continuity

Long Diaphragm span


Torsional Rotation Wall Warping and Possible Resulting Separation of Diaphragm
'Soft Story' with Inadequate Strength Can Result in Collapse

Torsional Problems

Vertical Discontinuity

Figure 7
Primary Collapse Merchanisms in URM Buildings

Source Based on an illustration in an article by Eric Elsesser, "Structural Concepts for Seismic Protection of Historic Buildings."

shear walls or braces are added. For this last element steel bracing and gunite are the most common materials. The steel solution typically employs a K or X brace system inserted into the structure, the idea being that the steel will resist the lateral forces that the masonry walls would not. The gunite solution involves the application of concrete to the existing masonry, increasing the shear resisting capabilities of these walls.

Recently, smaller residential buildings have begun to be seismically upgraded. Due in part to their numerous interior partitions, these buildings create different problems and opportunities for strengthening solutions. In some instances, interior plywood shear walls have been used as shear resisting elements. These buildings also raise the important question of the structural value of existing materials, which significantly impacts the design and cost. Descriptions of the currently practiced standard techniques follow on page 106.

ENGINEERING CASE STUDIES

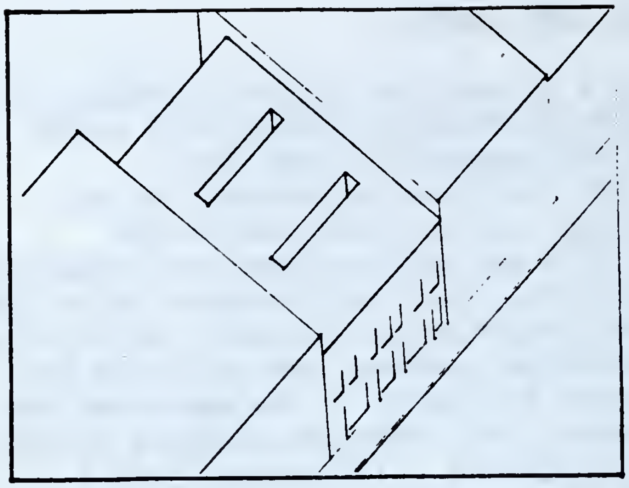
In order to assess the impact of a retroactive seismic ordinance in San Francisco, one must know how much the required upgrade work would cost. The existing information was not adequate to make this determination. Thus, we conducted the "Unreinforced Masonry Seismic Strengthening Workshop." This workshop examined prototypical San Francisco URM residential buildings in a way which allowed for comparison of strengthening methods, upgrading levels, building characteristics, and costs. It created a forum for several experienced engineers, architects and construction cost estimators to discuss problems and solutions for seismic upgrade. Based on the research done prior to the work-shop and the input from the workshop participants, the engineers proposed design solutions based on a common set of assumptions. This established a structure in which design work would be comparable in a systematic way.

Based on the San Francisco Seismic Hazards Survey data, prototypical building types were chosen. According to the survey, of the 2058 URM buildings in San Francisco, 90.2% are square or rectangular. Of the approximately 556 URM apartment and residential hotel buildings in the 17 census tracts which include the Tenderloin, Chinatown and Bush Street Corridor, 69% are 3 or 4 stories. Based on this data as well as field surveys and review of typical plans of apartments and residential hotels in these areas, typical building characteristics were assessed, including size, configuration, height, facade patterns, and general structural characteristics. Following this analysis, 5 actual buildings were chosen as prototypes to represent the base building and four variations.

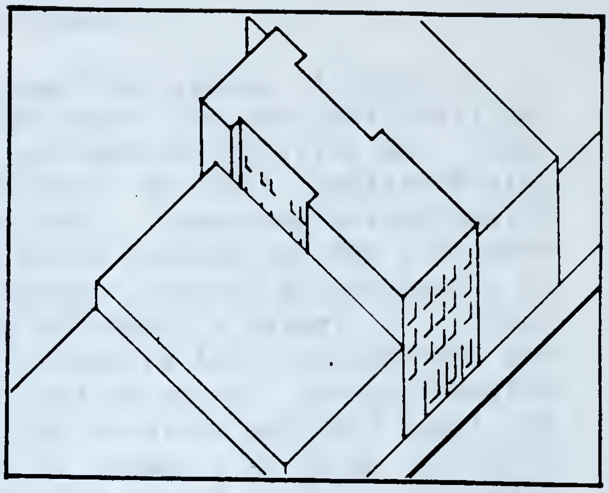
The 3-4 story rectangular building with commercial ground floor and double loaded corridor above is the most common, and thus defined as the basic prototype. The four other buildings are variations of this type: 2 stories, 6 stories, square, corner location, and L-shaped. (See Figure 8.) Architectural drawings of these buildings were produced, based on their original construction documents. In the few instances when these documents were incomplete, additional information was extrapolated from archival records of similar buildings. These prototypical buildings were then used to compare costs associated with different levels of upgrading, building characteristics and method of upgrading.

While variations in the building itself (e.g. height, footprint, configuration) cause some variations in seismic upgrade engineering design and cost, so too do the levels to which one designs and the methods of construction one employs. Four building upgrade scenarios, which included the building itself, the level to which it should be upgraded, and the prescribed strengthening method (steel or gunite), were given to each of four engineers to conceive and document preliminary solutions. Since the cost data would be based on the engineering design, it was critical to ensure that the assumptions used in the engineering solutions developed by the four engineers be consistent.

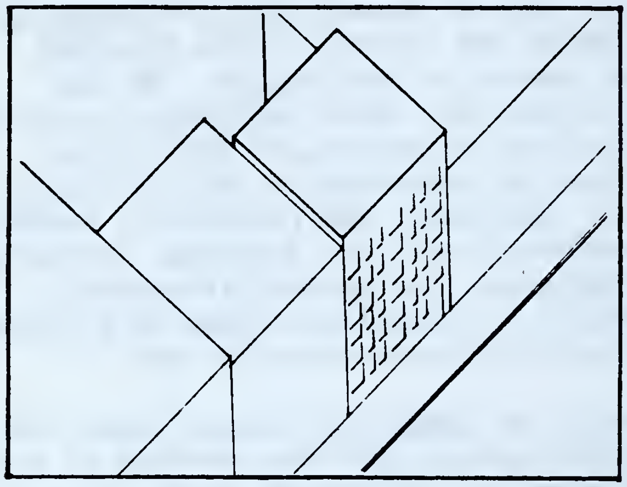
Each scenario prescribed a design solution of gunite or steel. For the purposes of the study, the engineers were asked to work within the



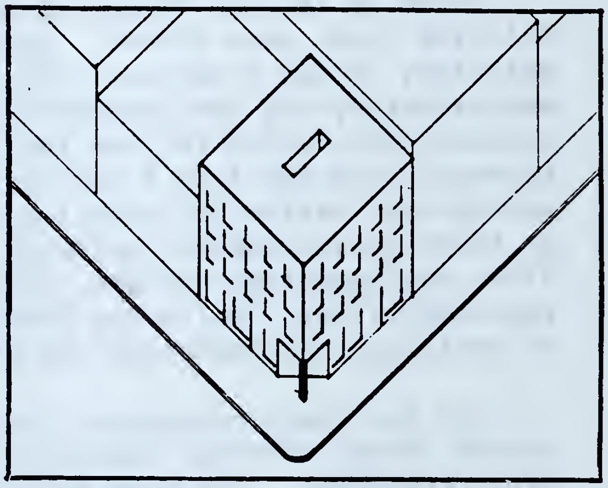
Building #1



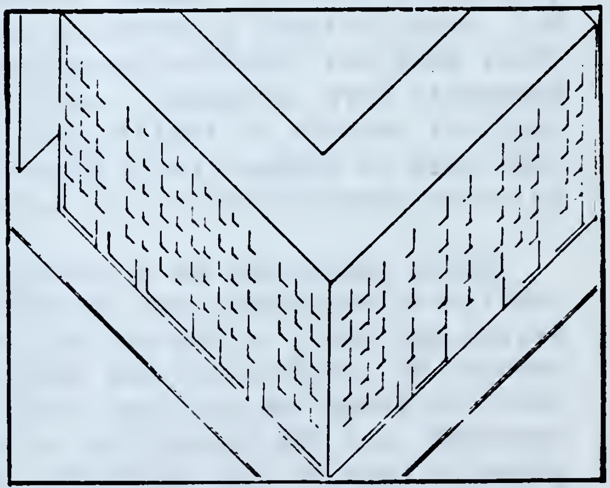
Building #2



Building #3



Building 4$



Building #5

Figure 8
Buildings Used in Enginering and Cost Study

range of traditional solutions, with the intention of clarifying cost relationships. The description of a steel or gunite solution was not meant to exclude the use of other materials, but as a base from which typical engineering designs could develop. In fact, solutions necessarily included typical wall-floor anchorage and other standard details. Additionally, the presence of many interior partitions added a variable not necessarily addressed in many steel or gunite solutions.

The prescribed seismic force requirements to which the engineers designed were based on levels designated in existing building codes. The actual code levels, however, were modified somewhat in the interest of clarity. The Level 1 lateral force requirement was based on the Los Angeles ordinance for existing pre-1934 URM buildings and set at 10% of the weight of the building (W). The Level 2 requirement was based on the 1973 Uniform Building Code (UBC) and set at 13.3%W, which is equivalent to San Francisco's current regulations for existing buildings undergoing substantial rehabilitation work. Level 3 was set at 18.6%W, based on the level established in 1976 and repeated through the 1985 edition of the UBC. In reality, the 1973 and 1985 UBC's lateral force requirements vary with the period of the building, which is dependent upon the relationship of its height to width and length. Generally, a tall building will have a longer period. The 1973 and 1985 UBC's lateral force requirements decrease as the building's period increases (See Figure 9.) This is because taller buildings generally have more flexibility and will resonate only with slow ground motion and will not be affected by short period quakes with higher acceleration. However, this relationship is not as pertinent for existing URM buildings. Additionally, for our prototypical buildings, the inclusion of this variable would have made the differences in levels 1 and 2 negligible. Thus, to clearly distinguish between these levels, they were held constant with respect to building period.

In order for the levels to be comparable, there must be consistency in the strength values given to existing materials. The values and allowable overstresses proposed by the Los Angeles code were essentially adopted for levels 1 and 2, with a few modifications. The allowable material stress values that the Los Angeles retroactive URM ordinance recognized are representative and very similar to those of other retroactive codes. Level 3 represents the most current regulations for new buildings and thus no values were set for existing materials. This is in fact an unlikely scenario for existing buildings, included only to document the spectrum of upgrading requirements and their attendant costs.

A proposed difference lies in the shear strength of existing masonry. The means to assess the actual shear resistance, such as an in-place push-test, are available for actual strengthening projects. To perform this test, one brick is removed from a wall and the mortar is removed. A calibrated hydraulic ram is then placed in the cavity of the removed brick and the ram applies a force to move the isolated brick. For the workshop, however, such building specific data was not appropriate, and it was agreed by the engineers that the actual values would be higher than the present nominal values as prescribed in the Los Angeles and Long Beach retroactive codes. It was clear that unless a

WORKSHOP STRENGTHENING LEVELS

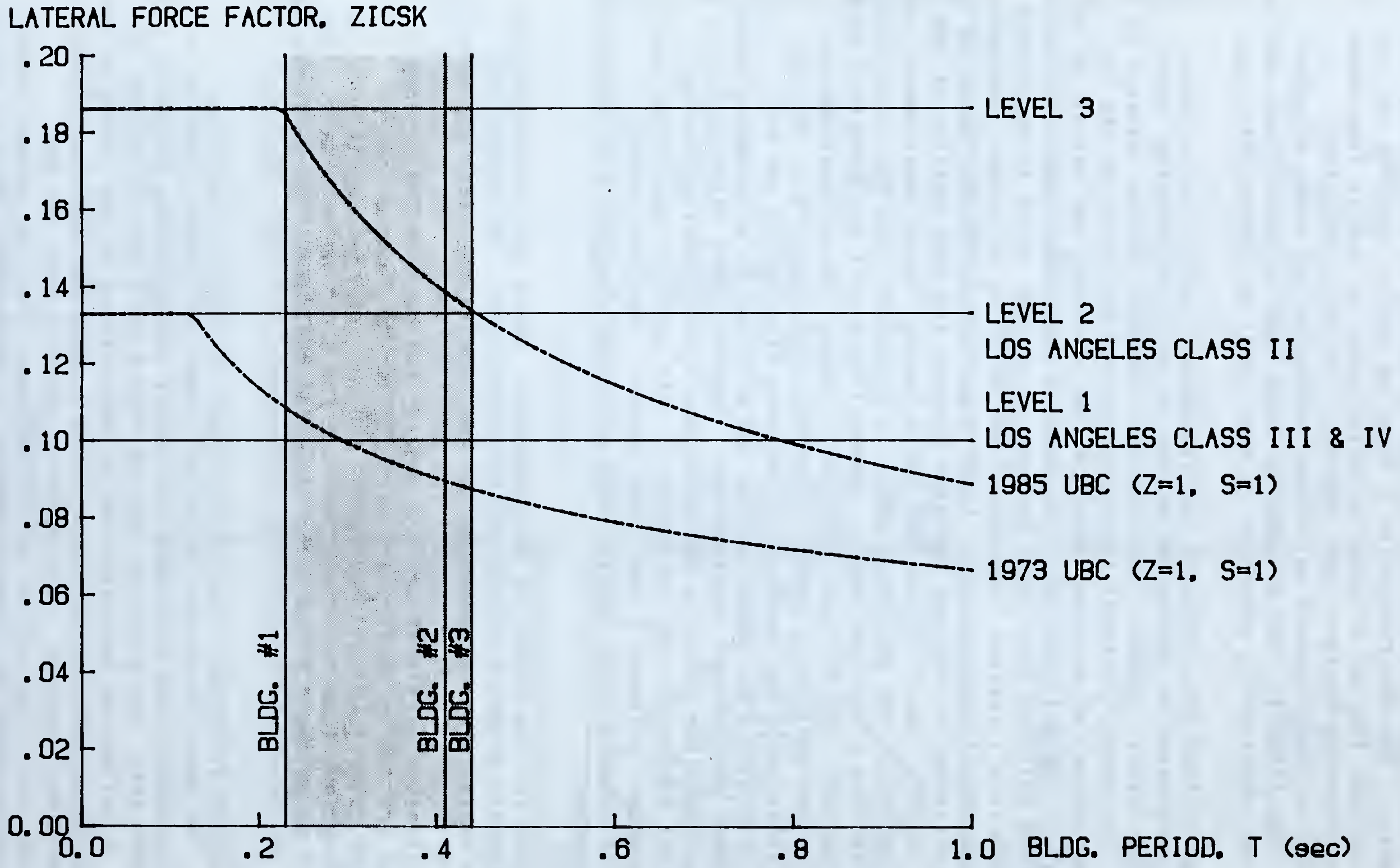


Figure 9

shear resistance of 10 pounds per square inch (psi) is developed in the existing brick, shear resistance of the building in the longitudinal direction probably cannot be provided by the URM walls without additional bracing, even at the lowest strengthening level (10%W.)

Holding assumptions about each design in common allows for comparison and evaluation of cost information and of each design. Thus it was clearly essential to establish appropriate values for strengthening levels and existing materials, as described previously. In addition, it was determined that the use of typical details for all of the design solutions would further aid the cost comparison. These details were based on those described by the Structural Engineering Association of California in its publication Earthquake Hazard Mitigation of URM Buildings Built Prior to 1934. By keeping these constant, it was possible to describe the costs in terms of each design component.

By clarifying the assumptions upon which the engineering designs are made, one can systematically compare the costs. These assumptions include characteristics of existing materials and conditions of buildings, the levels to which one is upgrading, and the construction details. No such systematic comparison of design scenarios for a given building had previously been done.

Group 1: Number of stories
  a. 2 stories
  b. 4 stories
  c. 6 stories

Group 2: Level of upgrade
  1. V = .1 W (max) L.A. ord. (for class III & IV)
  2. V = .133 W (max) '73 UBC L.A. ord. (Class II)
  3 V = .186 W (max) '83 UBC

Group 3: Methods of Strengthening
  a. Steel brace frame systems
  b. Concrete shear wall systems

Group 4: Footprint Size (Area)
  a. Small less than 2,200 sq. ft.
  b. Medium between 2,200 and 7,500 sq. ft.
  c. Large greater than 7,500 sq. ft.

Group 5: Building Configurations
  a. Basic rectangular
  b. L shaped
  c. Open ground story
  d. Corner buildings

Figure 10
Major Cost Determinants

ENGINEERING STRENGTHENING DESIGNS

The strengthening solutions all employed typical current methods of upgrading unreinforced masonry to bring the buildings up to specified levels of performance, based on resistance to seismically induced lateral forces. All of the solutions included parapet bracing, to keep the parapet from breaking off, and a system to tie the building together, to reduce to risk of the walls falling outward and the floors collapsing down or "pancaking". The remainder of each solution included varying techniques to ensure the integrity of the building's structural system under seismic loading; to control lateral displacement of walls; to pre-vent buckling of walls; and/or to address problems due to configuration. The variations in technique were a response to specifications of construction method, building characteristics, and required strengthening level.

The following section presents in further detail the collapse mechanisms and strengthening tasks recommended by the engineers. (For a more detailed description of the specific engineering designs, see Appendix 1, Section V.)

Bracing the parapet

In San Francisco, parapet bracing has been required in buildings whose parapets do not meet the 1969 UBC lateral force requirements since enforcement of the Parapet Ordinance began in the summer of 1975. At the workshop, though, for purposes of consistency, it was decided that all parapets were in need of strengthening. The accepted method was from SEAOC's Earthquake Hazard Mitigation of Unreinforced Masonry Buildings. This technique uses a system of steel diagonal bracing all around the perimeter and attached to the roof. No cornice or ornamentation strengthening was assumed. (See Figure 11.)

Tying the building together

During an earthquake, the walls of a building will try to pull away from the roof and floors. The shaking of walls will be out of phase from that of the floors and roof. In order that the exterior walls do not fall outward and the floors collapse down, the building must be tied together. This is typically accomplished by a three part system: wall anchors, shear bolts, and chords. (See Figure 12.)

Wall anchors, installed in the perimeter walls at floor and roof levels, strengthen the structural link between floors within the building and the exterior walls. Anchors are installed in a building's perimeter walls, with steel plates on the exterior and steel bolts connected to the anchors, placed between the floor joists within the building.

The earthquake forces not only try to separate the wall from the floors and roof, but also try to slide along the length of the wall and push out the end walls. URM buildings typically had no anchorage for these forces parallel to the wall. Shear bolts, usually introduced at 6' intervals, staggered between wall anchors, prevent this slippage between

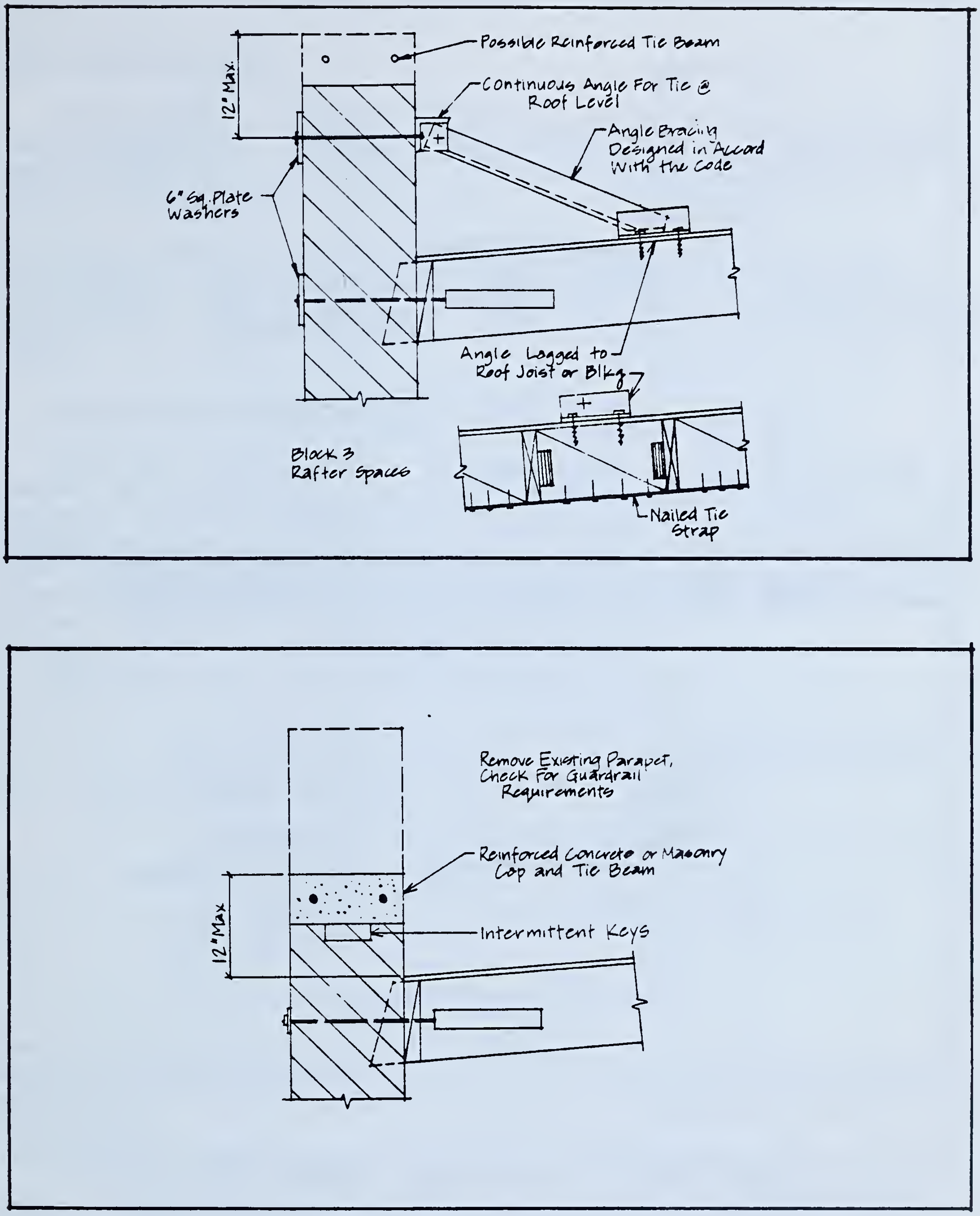
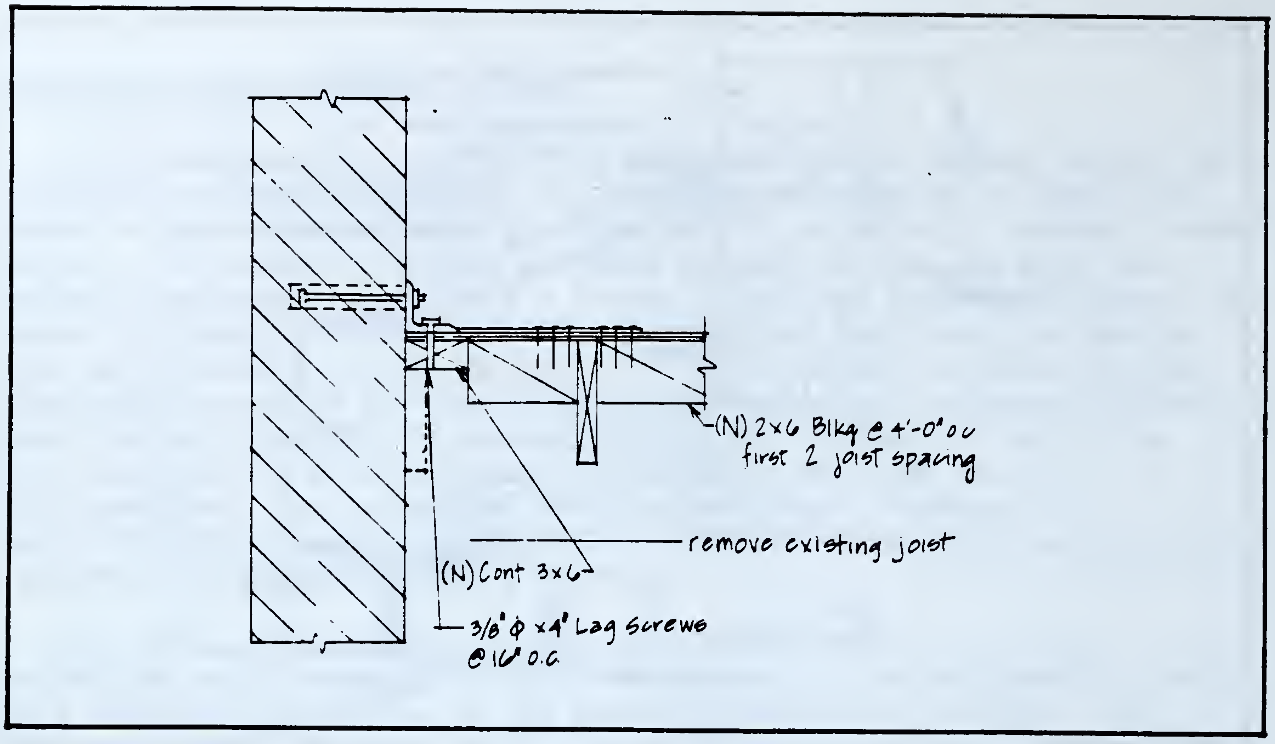
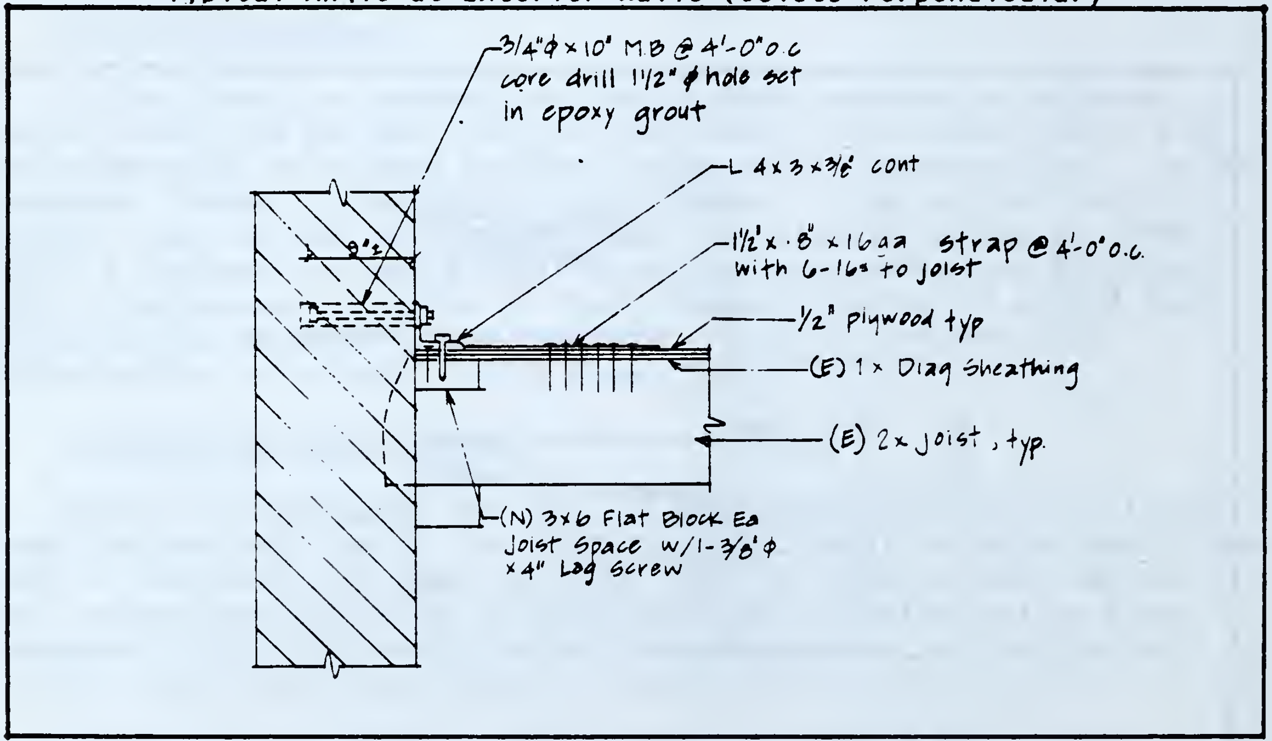

Possible Reinforced Tie Beam
12" Max.
Continuous Angle For Tie @ Roof Level
Angle Bracing Designed in Accord With the Code
6" Sq. Plate Washers
Angle Lagged to Roof Joist or Blkg.
Block 3 Rafter Spaces
Nailed Tie Strap
Remove Existing Parapet, Check For Guardrail Requirements
Reinforced Concrete or Masonry Cap and Tie Beam
12" Max
Intermittent Keys

Figure 11
Parapet Bracing Details Used For
Engineering and Cost Study

Source: Kariotis, John, "Strengthening Techniques - Bracing of Masonry Walls and Parapets," Earthquake Hazard Mitigation of Unreinforced Masonry Buildings Built Prior to 1934, SEAOSC.



Typical Angle at Exterior Walls (Joists Perpendicular)



Typical Angle at Exterior Walls (Joists Parallel)

Figure 12
Anchor, Shear Bolt and Chord/Collector Details
Use For Engineering and Cost Study

Source: Peter Culley

wall and roof/floors.

Steel angles, or chords, introduced around the floors and roof make each a strong unit. This can prevent vertical cracks throughout exterior walls or at corners. Such cords also help to minimize separation of parts of the building.

In the interest of consistency, it was assumed that none of the buildings had existing government anchors, band iron, or any other types of anchorage. Thus is was the case that all of the engineering solutions would call for new anchors, shear bolts, and chords at all floor and roof levels.

Assuring the integrity of the building's structural system

Shear wall reinforcement aims to assure the integrity of the load bearing walls, which carry loads down to the foundation. Generally, the perimeter walls are load bearing, running continuously from the foundation to the roof and structurally supporting it. Since these walls carry earthquake induced forces up through the building, as well as back down to the foundation, strengthening them increases the structural system's chances to remain functional and in tact.

There are four standard methods for reinforcing shear walls:

1. walls are stripped to their frame, then reblocked, braced and reinforced at ceiling and floor connections and new concrete footings are added at their base;

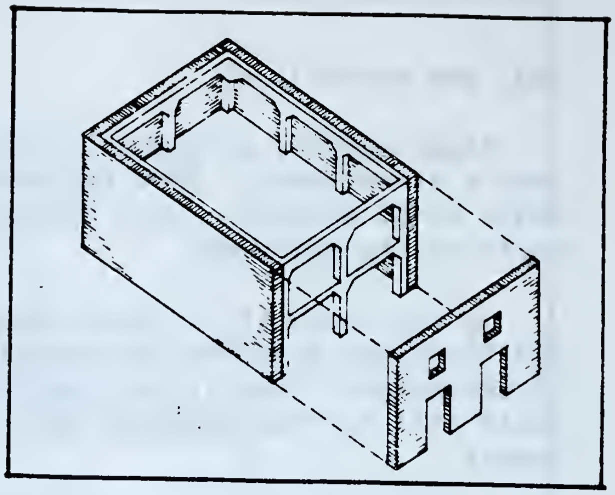
2. existing walls are fortified with gunite, concrete placed in direct contact with the existing masonry;

3. steel or concrete moment frames are added within the building; and

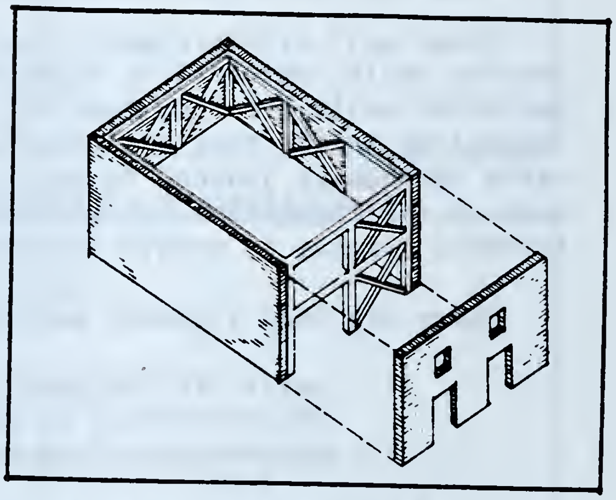
4. additional shear walls are constructed.

The first two methods strengthen the existing walls by either rebuilding them and/or adding more shear resisting material. The last two methods work by transferring some of the shear forces to other elements. (See Figure 13.)

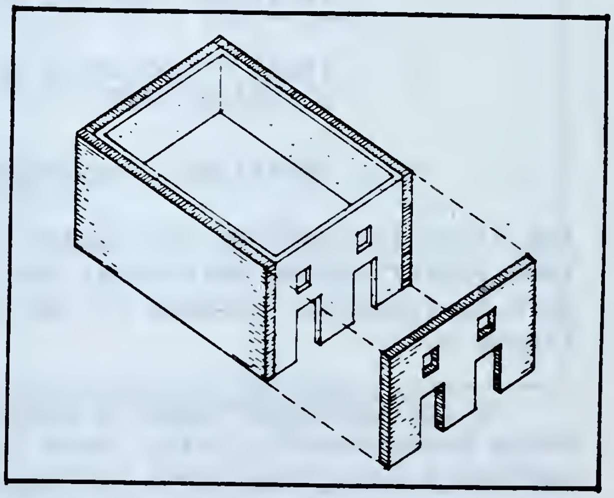
In the workshop scenario designs at level 1, the longitudinal walls, being predominantly solid, were found to offer adequate shear resistance and hence only transverse bracing was necessary. At level 2, both transverse and longitudinal bracing was necessary. At this level in the typical long rectangular building 2 longitudinal and 3 transverse braces were used. At level 3, a complete new vertical and horizontal load carrying system is needed in the upgrading process. This meant brace framing or new shear walls all the way around the building, and diaphragm strengthening at all levels.



Moment Resisting Frame



Braced Frame (typically steel)



Shear Wall (concrete)

Figure 13
Shear Wall Reinforcement

Source: Based on an illustration in Kirk Martini's, Unreinfirced Masonry Buildings: Seismic Behavior and Renovation, Center for Environmental Design Research, University of California, Berkeley.

Controlling lateral displacement

In an earthquake, the horizontal diaphragms (roof and floors) act to control the deflection of the walls. The diaphragms must be strong enough to deliver their attendant lateral forces to the vertical elements. There are three main methods:

1. adding another layer of sheathing to floors and roof;
2. providing a new horizontal bracing system, such as a steel truss;
3. decreasing the span of the diaphragm by adding new interior walls or strengthening existing ones.

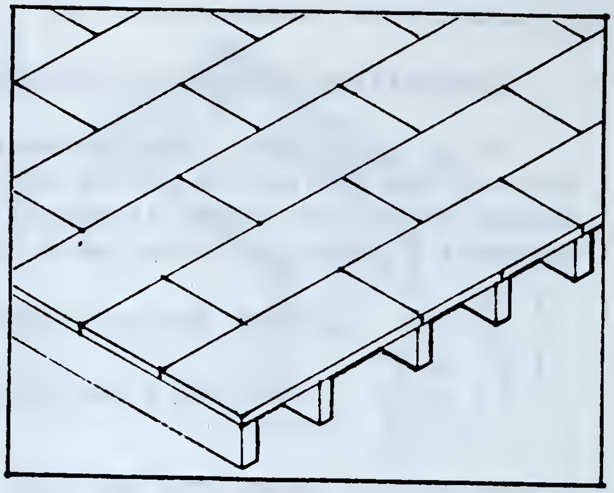
The first two methods increase the strength of the existing diaphragms, while the last reduces loads and consequently stress in the diaphragm, allowing the existing diaphragms to function without strengthening. The method of strengthening or adding interior walls to reduce diaphragm stresses is based on the premise that URM buildings are relatively rigid boxes that will typically respond to ground motion by moving with it laterally. One good way to control the sidesway is to utilize or add to the cross walls. If existing interior walls are adequately connected to the roof to accept the roof's shear loads, the lateral forces can be carried through several floors. Interior walls are a good path for lateral forces to follow to minimize large forces being transmitted to URM perimeter walls, to limit drift or sidesway of the building, and to permit the use of existing unstiffenend roof or floor diaphragms.

John Kariotis, a consulting engineer in the Los Angeles area who has for several years been researching and developing methods for upgrading URM buildings, has been a strong proponent of this technique. It has been a cost effective and workable solution in some buildings, while for others it has not proven to be viable. This technique is not typical-ly practiced in the San Francisco area, however, and thus was not used in the engineering design solutions.

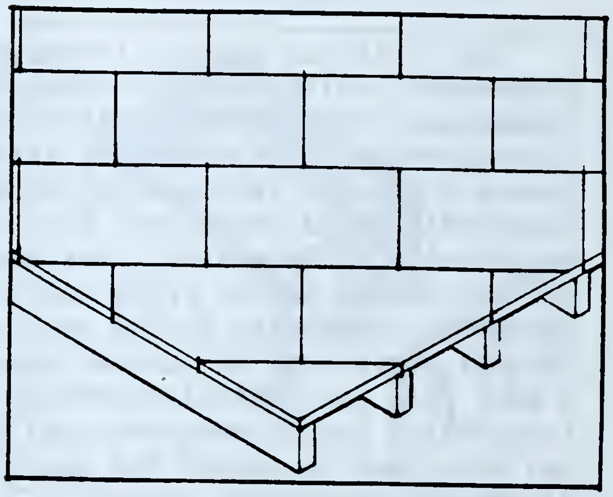
There are a variety of conditions in the floor and roof diaphragms of URM buildings. Diaphragms may be of diagonal or straight sheathing, with or without finish floors. The worst possible case was assumed for the design scenarios: straight sheathing without any strength contribution from the finish floor. To address the problem of the positive shear transfer between the plywood and the base of existing stud partitions, framing anchors were included. (See Figures 14 & 15.)

Preventing buckling of walls

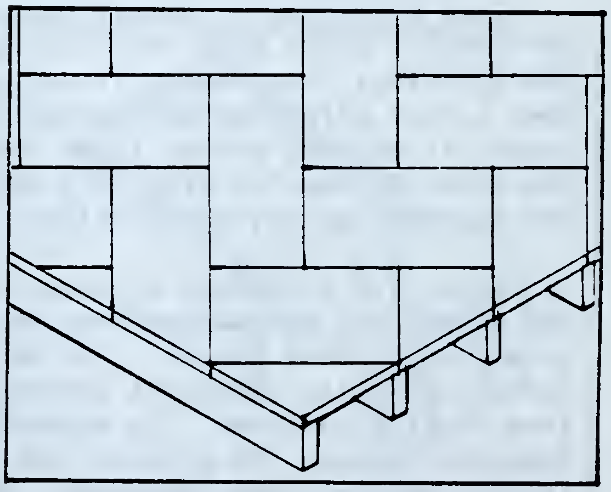
Another problem in buildings caused by lateral forces is the buckling of walls which do not meet height-thickness criteria. Those walls at the upper stories of multi-level buildings are often the thinnest and thus have the least resistance to lateral forces. In cases where this is a problem, interior vertical steel stiffeners were added to prevent out-of-plane bending. (See Figure 16.)



Straight Configuration



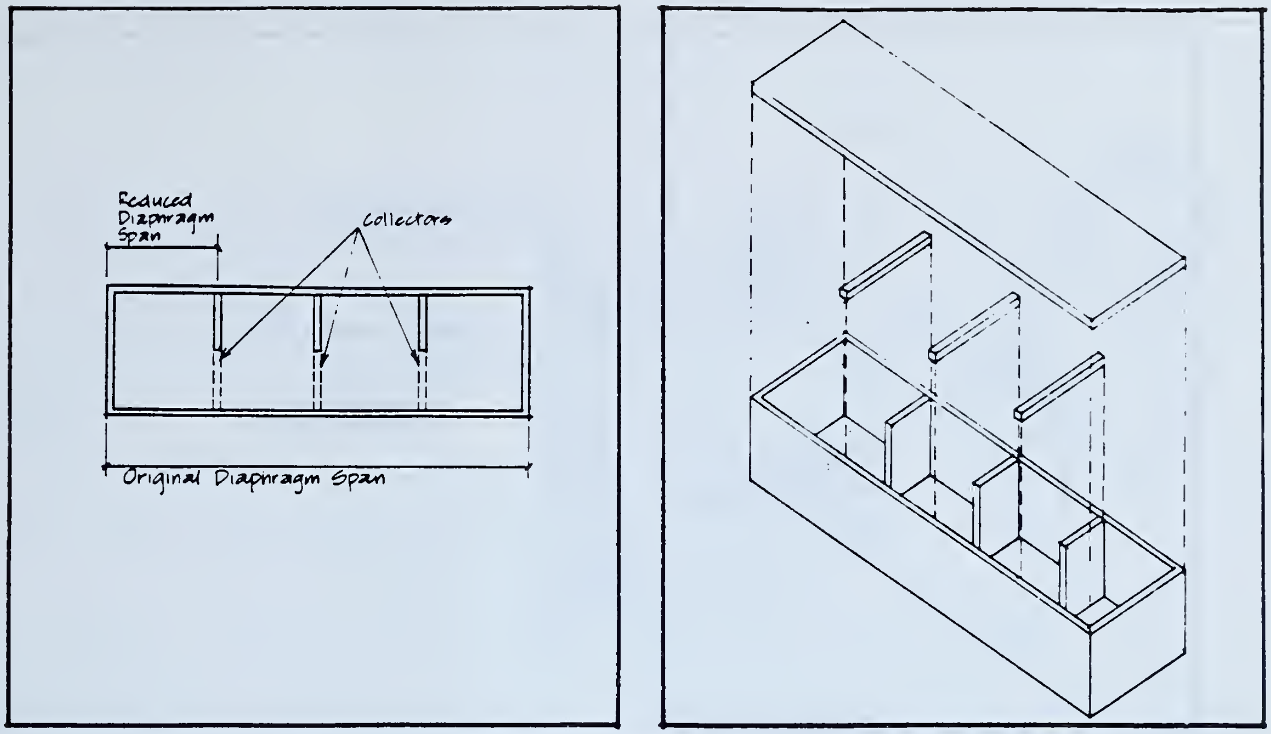
Diagonal Configuration



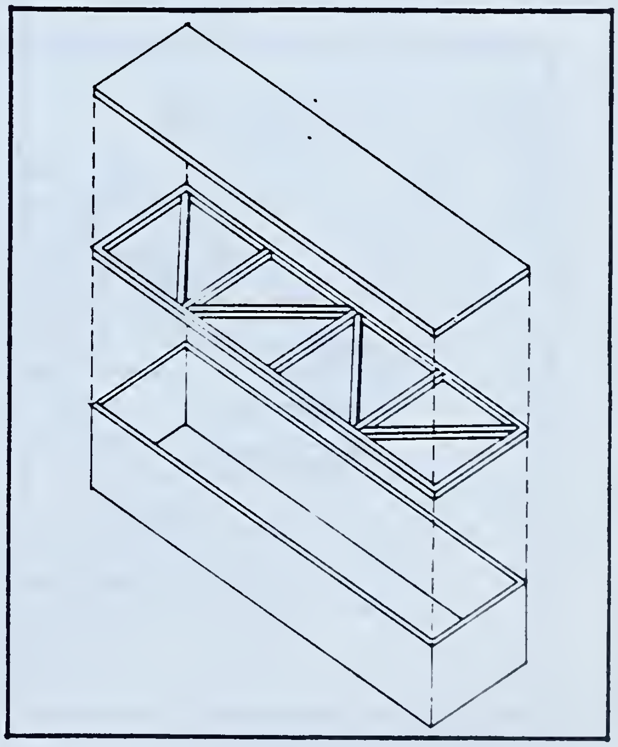
Woven Confriguration

Figure 14
Diaphragm Strengthening By Addition of Plywood Sheathing

Source: Lagorio, Henry J., Howard Friedman, and Kit Wong, Issues for Strengthening of Existing Buildings: A Environmental Guide for Architects, Center for Environmental Sesign Research, University of California, Berkekely.



Additional Interior Shear Walls Are Sometimes Used To Reduce Forces In Diaphragms And Walls



Horizontal Trusses May Be Used To Strengthen Diaphragms

Figure 15
Diaphragm Strengthening By Addition of Interior Shear Walls or Horizontal Steel Truss

Source Based on an illustration in Kirk Martini's, Unreinforced Masonry Buildings: Seismic Behavior and Renovation, Center for Environmental Design Research, University of California, Berkeley.

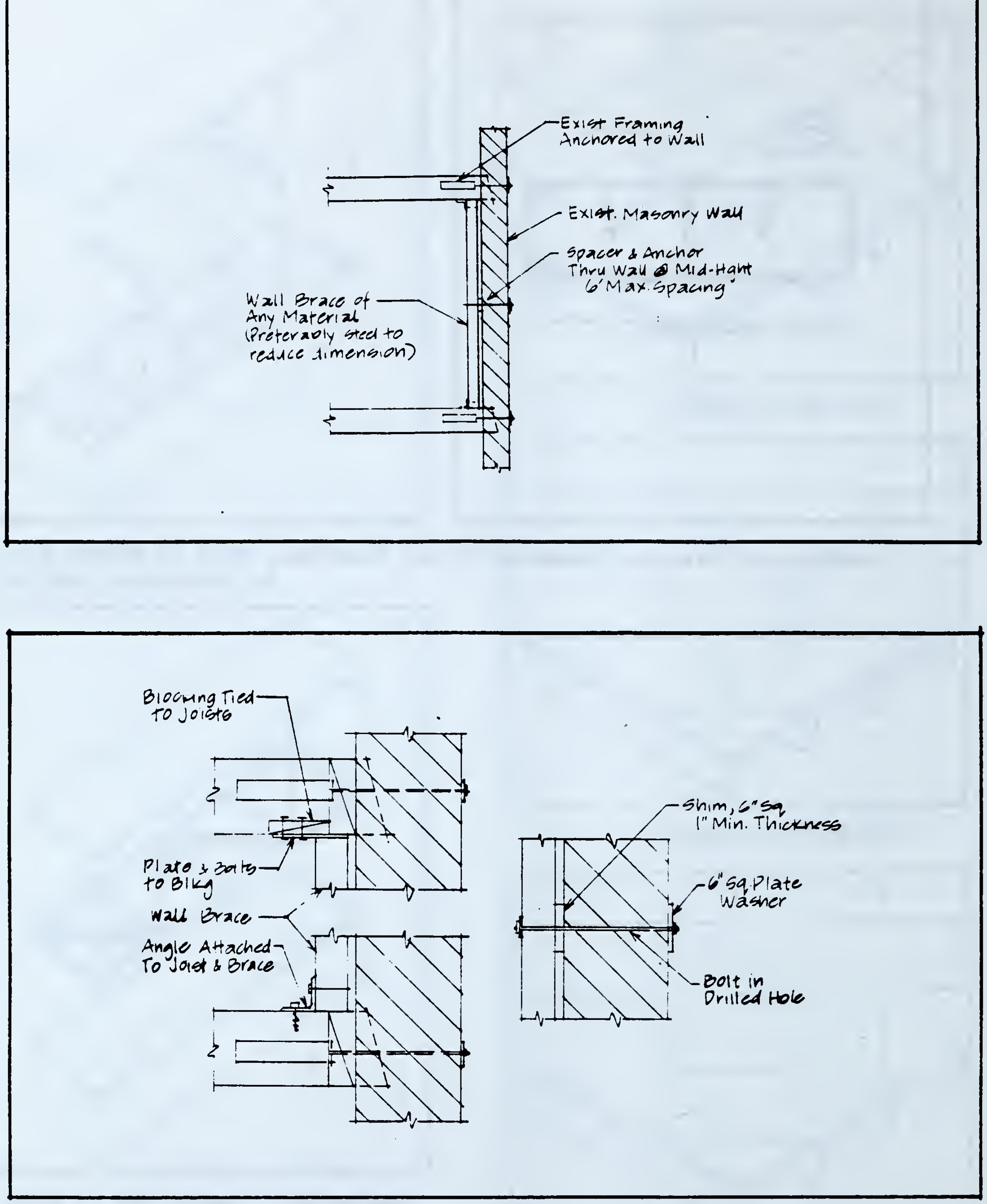
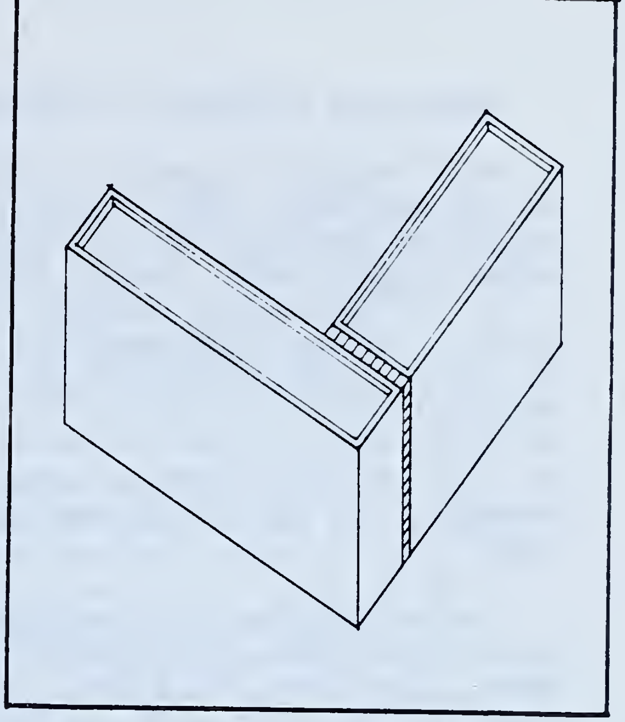
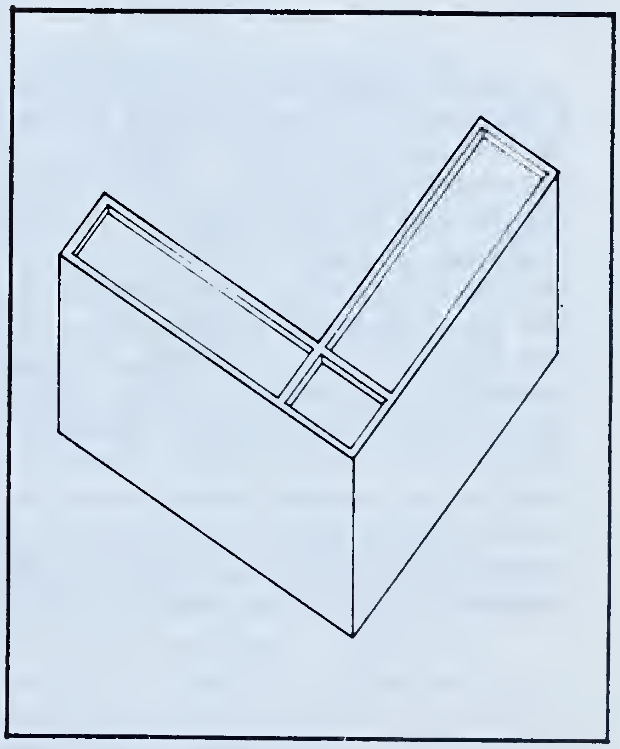

Exist Framing Anchored to Wall
Exist. Masonry Wall
Spacer & Anchor Thru Wall @ Mid-Haht 6' Max. Spacing
Wall Brace of Any Material (Preferably steel to reduce dimension)
Blocking Tied to Joists
Plate & Bolts to Blkg
Wall Brace
Angle Attached To Joist & Brace
Shim, 6" Sq, 1" Min. Thickness
6" Sq. Plate Washer
Bolt in Drilled Hole

Figure 16
Out-of-Plane Bracing Details Used for
Engineering and Cost Study

Source: Kariotis, John, Strengthening Techniques - Bracing of Masonry Walls and Parapets," Earthquake Hazard Mitigation of Unreinforced Masonry Buildings Built Prior to 1934, SEAOSC.



Legs Structurally Separated



Legs Structurally Tied

Figure 17
Strengthening of L-Shaped Buildings

Source Based on an illustration in Kirk Martini's, Unreinforced Masonry Buildings: Seismic Behavior and Renovation, Center for Environmental Design Research, University of California, Berkeley.

Addressing problems of configuration

Buildings with eccentric configurations present special problems for seismic upgrading. One example is an L-shaped building, which may experience damage at its junctions since the legs, oriented at right angles to each other, respond differently to ground motion. One solution is to tie the two legs together so that they do not break apart as a result of different responses to ground motion. The solution described for the L-shaped building of the workshop involves a "seismic cut", which separates the legs structurally so that each can vibrate independently. The solution calls for the removal of about one foot of masonry, floors, etc. out of the existing structure at the corner, allowing space for movement. The gap is replaced with a metal expansion joint. (See Figure 17.)

Corner buildings also experience torsional, or rotational problems due to differences in stiffness because of extensive openings on two faces. Sometimes this allows for just two rows bracing on the open sides, but in other cases the torsional problems necessitate further bracing. For the corner building scenario the design solution calls for bracing to be added on all four sides at the perimeter of the building.

These descriptions should not imply that seismic renovation is simply a process of strengthening those elements which are not strong enough to resist certain lateral forces. In fact, it is a process which must address the building's structural system as a whole. When one element is reinforced to increase its strength, its stiffness will almost certainly increase as well, altering the stiffness distribution of the whole structural system. An example is the complex decision making process for how to strengthen diaphragms. Aside from cost considerations regarding the addition of sheathing, bracing systems, or vertical shear resisting elements, one must account for the greater forces now being transferred to the other structural elements. If the forces which are now transferred to existing shear walls are too high, then these walls may need to be strengthened beyond a reasonable point. Further, functional requirements of a building will be likely to influence the most desirable upgrading solution. As in new buildings, structural systems must be adapted to suit the needs of the building's occupants.

COST ANALYSIS

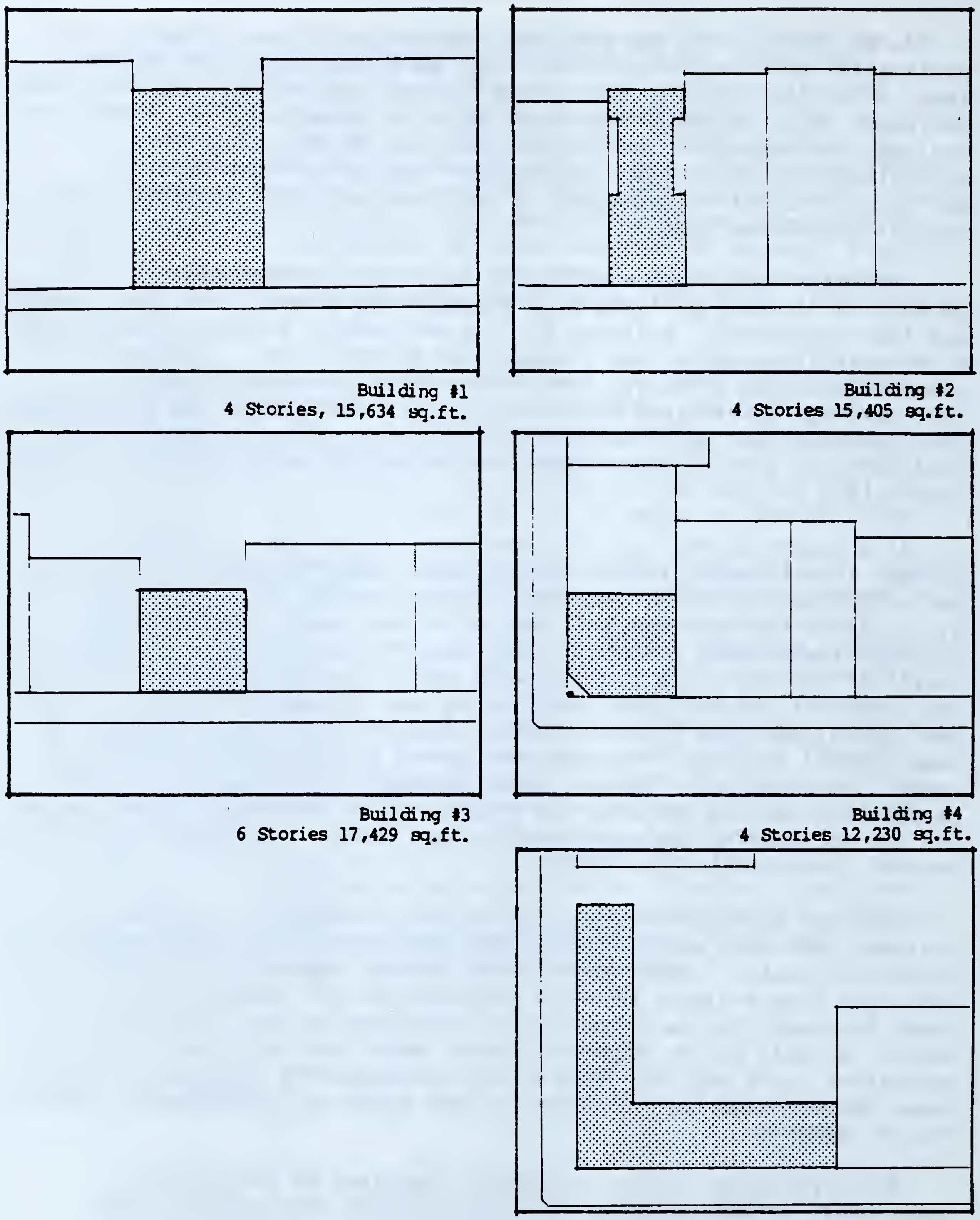
In preparation for the workshop, typical variations in URM residential buildings were identified. Workshop discussions addressed these variations, associated seismic hazards, and methods commonly used to reduce these hazards. Important building characteristics identified included configuration, height, and location on the block. The strengthening scenarios were designed to represent these typical variations and the cost analysis of each scenario then estimated the typical associated costs.

The set of buildings used in the scenarios includes a basic rectangular 4-story building with a commercial ground floor (Building #2) and four variations. Building #1 is a rectangular 2-story building with a residential mezzanine and a commercial ground floor. Building #3 is almost square and 6 stories. While Buildings #1-3 are of basic configuration and located mid-block, Buildings #4 and #5 are of eccentric configuration and located on corners, with the former having a square configuration with two open faces and the latter being L-shaped. (See Figure 18.)

As a result of the July 1st workshop, engineering strengthening designs corresponding to 14 scenarios were completed and submitted by the participating consulting engineers. These preliminary designs were used as inputs to the cost analysis portion of the study. The designs, although approximate in nature, described the configurations and the extent of the necessary strengthening work. The submitted drawings show the Footprints of Buildings Used in Engineering and Cost Study location and approximate size of new structural members to be added as well as some typical details. The engineers agreed at the start that all the design solutions will include joist anchorage, shear bolting, chords, parapet bracing and out-of-plane bracing where necessary. These items are not included in the submitted drawings as the associated costs can be derived from standardized details.

Upon the engineers' completion of the preliminary strengthening designs, each cost estimator analyzed the solutions and estimated the associated costs. These figures were checked against actual construction cost data from projects recently completed in Los Angeles. Table 19 shows the costs for each scenario as estimated by John Robertson and Lee Saylor, as well as the adjusted figures which are based on the two cost estimators' work and data from actual strengthening projects. Table 20 shows the adjusted cost estimate of each piece of strengthening work for the 14 scenarios.

The differences in cost estimates submitted by the two cost consultants reflect a factor of uncertainty of construction costs associated with the renovating of older buildings. As Table 3 in Appendix 1 indicates, there are only minor differences in the estimate of the unit structural costs, as these costs are relatively predictable. The uncertainty in the estimates is due to the unknown existing conditions, which is reflected in the large differences in the architectural and demolition cost estimates. Further, the unknown



Building #1
4 Stories, 15,634 sq.ft.

Building #2
4 Stories 15,405 sq.ft.

Building #3
6 Stories 17,429 sq.ft.

Building #4
4 Stories 12,230 sq.ft.

Building #5
6 Stories 48,542 sq.ft.

Figure 18
Buildings Used in Enginering and Cost Study

	BUILDING 15,634 SQ.				BUILDING #5 48,542 SQ. FT.			
	Steel		oncrete		Steel		Concrete	
	$/Sq Ft	Total $	$/	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $
LEVEL 1 Adjusted Estimate	11.93[2]	186,566	1					
Robertson Estimate	12.14[2]	189,821	1					
Saylor Estimate	9.43[2]	147,411						
LEVEL 2 Adjusted Estimate	21.72	339,557					22.97	1,114,814
Robertson Estimate	19.71	308,181					22.69	1,101,409
Saylor Estimate	15.79	246,892					18.45	895,462
LEVEL 3 Adjusted Estimate								
Robertson Estimate								
Saylor Estimate								

Notes:

1. Cost based on bracing on four sides. If only

2. Probably low estimates, based on range approxi

Table 19
URM Seismic Cost Study Summary

	BUILDING #1 15,634 SQ. FT.				BUILDING #2 15,405 SQ. FT.				BUILDING #3 17,429 SQ. FT.				BUILDING #4 12,230 SQ. FT.				BUILDING #5 48,542 SQ. FT.			
	Steel		Concrete		Steel		Concrete		Steel		Concrete		Steel		Concrete		Steel		Concrete	
	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $
LEVEL 1 Adjusted Estimate	11.93[2]	186,566	12.45[2]	194,645	15.44	237,906	15.99	246,250	22.33	389,109	20.28	353,505								
Robertson Estimate	12.14[2]	189,821	13.17[2]	205,943	14.37	221,405	15.87	244,405	18.93	329,903	18.79	327,526								
Saylor Estimate	9.43[2]	147,411	9.34[2]	146,081	12.24	188,590	11.92	183,602	18.63	324,725	16.70	291,131								
LEVEL 2 Adjusted Estimate	21.72	339,557			20.34	313,408	22.27	343,039	24.24	422,404	25.21	439,452	26.04[1]	318,502					22.97	1,114,814
Robertson Estimate	19.71	308,181			18.21	280,529	23.00	354,270	20.55	358,129	22.92	399,401	21.42[1]	262,007					22.69	1,101,409
Saylor Estimate	15.79	246,892			16.72	257,600	18.28	281,650	20.16	351,425	20.87	363,718	22.05[1]	269,664					18.45	895,462
LEVEL 3 Adjusted Estimate							38.16	587,866												
Robertson Estimate							36.79	566,701												
Saylor Estimate							30.26	466,095												

Notes:

1. Cost based on bracing on four sides. If only the two open sides are braced, the cost would be approximately $4.00/sq.ft. less.

2. Probably low estimates, based on range approximation of material quantity.

Table 19
URM Seismic Cost Study Summary

	BUILDING 15,634 SQ.				BUILDING #5 48,542 SQ. FT.			
	Steel		Concrete		Steel		Concrete	
	$/Sq Ft	Total $	$/ t	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $
LEVEL 1								
Seismic Cut	.00	0						
Anchorage System	3.05	47,644						
Parapet Bracing	1.21	18,920						
Out of Plane	.58	9,116						
Diaphraphms	4.09	63,915						
Transverse Shear Walls	2.58	40,381						
Longitudinal Shear walls	.00	0						
TOTAL*	11.93	$186,566	1					
LEVEL 2								
Seismic Cut	.00	0					1.56	75,530
Anchorage System	3.05	47,644					4.17	202,210
Parapet Bracing	1.21	18,920					.61	29,700
Out of Plane	.58	9,116					.00	0
Diaphraphms	4.46	69,739					2.74	133,014
Transverse Shear Walls	11.63	181,759					7.27	353,088
Longitudinal Shear walls	.00	0					6.62	321,273
TOTAL*	21.72	$339,557					22.97	1,114,814
LEVEL 3								
Seismic Cut								
Anchorage System								
Parapet Bracing								
Out of Plane								
Diaphraphms								
Transverse Shear Walls								
Longitudinal Shear walls								
TOTAL*								

	BUILDING #1 15,634 SQ. FT.				BUILDING #2 15,405 SQ. FT.				BUILDING #3 17,429 SQ. FT.				BUILDING #4 12,230 SQ. FT.				BUILDING #5 48,542 SQ. FT.			
	Steel		Concrete		Steel		Concrete		Steel		Concrete		Steel		Concrete		Steel		Concrete	
	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $	$/Sq Ft	Total $
LEVEL 1																				
Seismic Cut	.00	0	.00	0	00.	0	.00	0	.00	0	.00	0								
Anchorage System	3.05	47,644	3.05	47,644	5.50	84,762	5.50	84,762	5.57	98,889	5.67	98,889								
Parapet Bracing	1.21	18,920	1.21	18,920	1.09	16,720	1.09	16,720	.64	11,220	.64	11,220								
Out of Plane	.58	9,116	.58	9,116	.52	8,056	.52	8,056	.00	0	.00	0								
Diaphraphms	4.09	63,915	4.09	63,915	1.97	30,308	1.97	30,308	5.25	91,480	5.25	91,480								
Transverse Shear Walls	2.58	40,381	3.08	48,150	5.80	89,285	6.34	97,713	5.32	92,750	6.46	112,595								
Longitudinal Shear walls	.00	0	.00	0	.00	0	.00	0	4.65	81,125	1,57	27,434								
TOTAL*	11.93	$186,566	12.45	$194,645	15.44	$237,906	15.99	$246,250	22.33	$389,109	20.28	$353,505								
LEVEL 2																				
Seismic Cut	.00	0			.00	0	.00	0	.00	0	.00	0	.00	0					1.56	75,530
Anchorage System	3.05	47,644			5.50	84,762	5.50	84,762	5.67	98,889	5.67	98,889	5.82	71,189					4.17	202,210
Parapet Bracing	1.21	18,920			1.09	16,720	1.09	16,720	.64	11,220	.64	11,220	.00	0					.61	29,700
Out of Plane	.58	9,116			.52	8,056	.52	8,056	.00	0	.00	0	.00	0					.00	0
Diaphraphms	4.46	69,739			1.97	30,308	1.97	30,308	5.25	91,480	5.25	91,480	7.53	92,058					2.74	133,014
Transverse Shear Walls	11.63	181,759			9.45	145,554	12.36	190,375	6.41	111,600	10.15	176,983	5.84	71,412					7.27	353,088
Longitudinal Shear walls	.00	0			1.06	16,376	.00	0	5.41	94,300	2.63	45,875	5.95	72,810					6.62	321,273
TOTAL*	21.72	$339,557			20.34	$313,408	22.27	$343,039	24.24	$422,404	25.21	$439,452	26.04	$318,502					22.97	1,114,814
LEVEL 3																				
Seismic Cut							.00	0												
Anchorage System							5.50	84,762												
Parapet Bracing							1.09	16,720												
Out of Plane							.00	0												
Diaphraphms							4.96	76,458												
Transverse Shear Walls							12.40	191,026												
Longitudinal Shear walls							12.86	198,185												
TOTAL*							38.16	$587,866												

Table 20
Adjusted Cost Estimates for Strenghening Work

existing conditions, which is reflected in the large differences in the architectural and demolition cost estimates. Further, the unknown conditions are greater for this study as the cost estimator cannot be provided with comprehensive data from on-site investigation, engineering testing, and detailed architectural surveys of the existing conditions.

From the submitted cost estimates, a composite estimate was compiled, generally following the conservative estimate. Data recorded from actual strengthening case studies was also used as a guide in formulating the composite estimate. (See Tables 19 and 20.)

COST COMPARISONS

From the accumulated data, individual prototypical buildings can be analyzed in terms of the different levels of upgrading. Further, cost comparisons can be made on the basis of strengthening method, building height, and configuration.

The variations in design solutions which most dramatically impacted upgrading costs were primarily in response to building characteristics (e.g. height) and strengthening level. These design variations include 1.) size and quantity of braces and additional shear walls; 2.) method of diaphragm strengthening; and 3.) special techniques for addressing problems of configura-tion (e.g., a "seismic cut" for the L-shaped building). Thus building characteristics and strengthening level impact upgrading designs and, consequently, upgrading costs. For example, the costs associated with building height and strengthening level can be seen by comparing Buildings #1, 2 and 3, all of basic configuration but varying in height. While the cost per square foot of a wall anchorage system re-mains constant, the costs associated with seismic strengthening to levels 1 and 2 increase with building height. (See Table 21.)

Cost Per Square Foot

	Wall Anchorage	Level 1	Level 2
Bldg. #1 (2 stories)	$6	$13	$21
Bldg. #2 (4 stories)	$6	$16	$23
Bldg. #3 (6 stories)	$6	$21	$25

Table 21
Approximate Cost of Seismic Strengthening

Most Common San Francisco Building

For prototype Building #2, the costs for seismic upgrading range from approximately $6 per square foot for a wall anchorage system to over $30 per square foot for a solution which would bring the building to current Uniform Building Code standards. This 4-story rectangular building represents the most common type of residential building in San Francisco in terms of physical characteristics. The building used for prototype #2 has a high (15 foot) first story with an open front. Further, it has a poor aspect ratio (i.e., it is very long and narrow). These characteristics influence the costs of all the upgrading solutions, but in particular the costs of the "minimum upgrade". To ensure stability, the minimum upgrade of Building #2 must go beyond the most basic steps of wall anchorage and parapet bracing to include three rows of bracing, at the front of the building and at the indentation lines, at least on the ground floor. This solution assumes that the partitions above will act to support the upper stories[4]

A level 1 upgrade of Building #2 includes two rows of transverse bracing and minimal longitudinal bracing. A level 2 upgrade includes a third row of bracing. When strengthening Building #2 to level 3, substantial reinforcement of longitudinal walls is needed in addition to the transverse bracing. (See Figure 19.) Further raising the costs is the necessity of horizontal trusses to alleviate diaphragm stresses as opposed to plywood sheathing. As would be expected, costs rise with strengthening level, with the largest jump being from level 2 to 3. (See Table 22.)

Upgrade Cost	Building #2 Per Square Foot ($)
Wall Anchorage System	$ 6.00
"Minimum Upgrade"	$10.40 (a)
Level 1	$15.40 (b)
Level 2	$20.30 (b)
Level 3	$38.20 (c)

(a) Approximate cost extrapolated from scenario #5.
(b) Steel solution
(c) Concrete solution

TABLE 22
Approximate Costs of Seismic Strengthening

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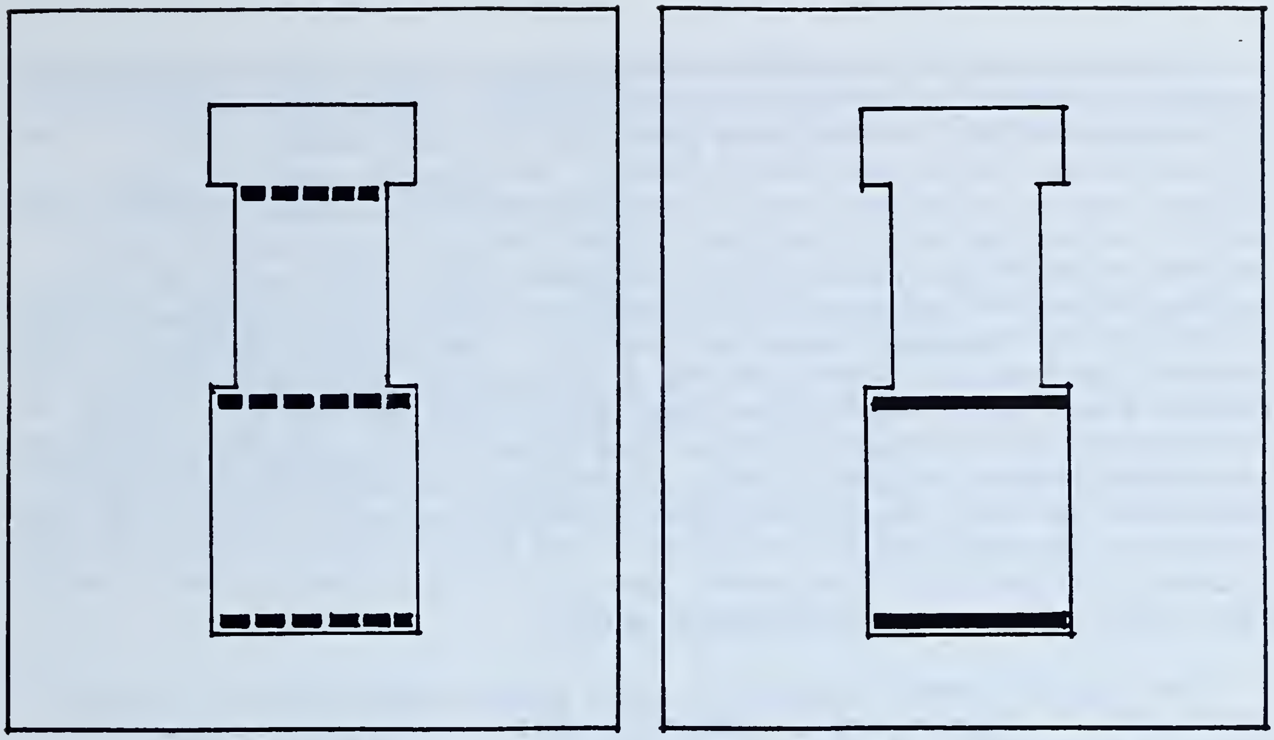
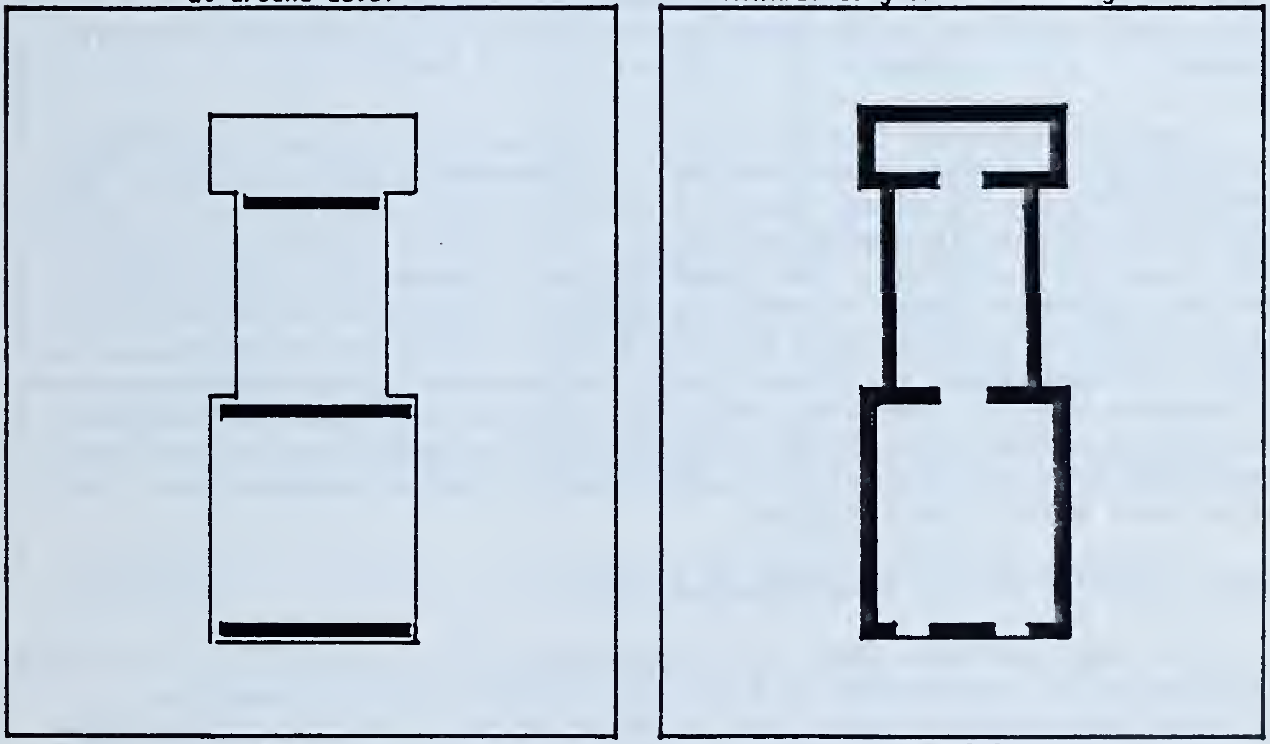
[4] In some buildings, it is possible that a wall anchorage system will bring the building to the minimum acceptable standard as outlined by the workshop participants. This minimum is a function of the length of floor spans, number and type of openings, and building configuration.



"Minimum Upgrade":
3 Rows of Transverse Bracing
at Ground Level

Level 1:
2 Rows of Tranverse Bracing,
Minimal Longitudinal Bracing



Level 2:
3 Rows of Transverse Bracing,
Minimal Longitudinal Bracing.

Level 3:
3 Rows of Tranverse Bracing
Longitudinal Bracing

Figure 19
Bracing Schematics for Building #2

The other scenarios represent variations of this basic building and as such the costs reflect the associated range. The major cost differences reflect the building characteristics of height and configuration, and strengthening level. For example, when all other factors are held constant, the price jump for the concrete solution at level 1 associated with a building height increase from four to six stories is $4.30 per square foot. Secondary cost differences reflect building specific characteristics, such as aspect ratio, location in the block, and the type and number of openings. The minimum upgrade of Building #2 illustrates this, as it could possibly have been achieved through a wall anchorage system alone were it not for its poor aspect ratio and high first story with an open front. In sum, building height and configuration influence patterns of major cost variations, while individual building characteristics will have a secondary impact and can affect the general pattern.

COST VARIATION DUE TO STRENGTHENING METHOD

The cost variation between the steel brace method and the concrete shear wall or frame method is generally small. A concrete system is slightly more expensive due to high labor cost. However, the difference in cost is only associated with the cost of the transverse and longitudinal bracing system. The costs for anchorage, parapet, diaphragm, etc. are not affected by the choice of a concrete or steel system.

For strengthening levels 1 and 2, longitudinal bracing in the basic rectangular building is very minimal. Therefore, since often only the transverse brace is added, the cost variation only affects 30% to 50% of the total seismic strengthening costs. In higher strengthening levels and in taller buildings, the steel system is potentially less expensive, but not substantially. The small variation in cost is easily offset by the difference in individual bracing design. Since the differences in steel configurations are broad, their cost can easily exceed the cost of a concrete system. The cost comparison between the steel and concrete systems is presented in Table 23. It should be noted however that the cost data does not reflect the substantially shorter construction time associated with a steel system.

Cost Variation Due to Strengthening Level

The data indicates that the strengthening level affects the cost more substantially in Buildings #1 & 2. This effect is due perhaps to building configuration more than building height. The substantial jump in cost in Buildings #1 & 2 is probably for the additional line of transverse bracing at level 2 in response to high diaphragm stress. On the other hand, the more stringent strengthening requirements did not affect Building #3 as dramatically. The added requirement did not call for more lines of bracing but just larger member sizes.

One can clearly see a large jump in cost associated with the level 3 strengthening requirement. (Level 3 corresponds to current UBC.) The dramatic increase in cost is due to the need to substantially reinforce longitudinal walls as well as transverse walls. Furthermore, diaphragm strengthening with plywood sheathing cannot achieve sufficient strength and stiffness; more expensive horizontal steel trusses must be used.

Cost Variation Due to Building Height

The cost of seismic work generally increases with building height. Table 23 shows that at level 1, Building #3 is substantially higher in cost than Buildings #1 and #2. This is mainly attributed to the fact that Building #3 has 2 lines of longitudinal bracing as well as 2 lines of trans-verse bracing, where Buildings #1 and #2 have only two lines of transverse bracing. The cost difference again is due to the number of braces rather than the size of braces. The level 2 cost relationships between Buildings #1, 2, 3 are more indicative of the cost variation due to height as Building #1 & #2 are strengthened with 3 lines of bracing. Probably low estimates, based on rough approximation of material quantity.

Cost Per Square Foot ($)

	Level 1	Level 2	Level 3	
Bldg. #1 (2 stories)	11.90 *	21.70	-------	Steel
	12.50 *	------	-------	Concrete
Bldg. #2 (4 stories)	15.40	20.30	-------	Steel
	16.00	22.30	38.20	Concrete
Bldg. #3	22.30	24.20	-------	Steel
	20.30	25.20	-------	Concrete

* probably low estimates, based on rough approximation of material quantity.

Cost Variation Due to Building Configuration

Building configuration clearly has an effect on reconstruction cost. In basic rectangular buildings, the general strengthening includes 2 or 3 lines of transverse bracing with minimal longitudinal bracing. In small buildings with square plans it may be necessary to substantially strengthen both longitudinal and transverse walls, thus incurring a higher cost. In corner buildings, torsional problems may occur. Although the building code as rules against torsional situations, a specific method for strengthening is not prescribed. With the recognition that torsion is a problem in corner Building #4, the cost estimate is based on a solution with four lines of bracings, one at each perimeter wall. The cost of strengthening ($26.00 per sq.ft.) reflects this additional requirement.[5]

In L-shaped buildings or buildings with reentrant corners, it may be necessary to provide a seismic separation cut. Again, this is an item not specifically required by code but is the method chosen in the upgrade of Building #5 to address the problems associated with this configuration. This work will of course drive the cost of retrofit up. (See Table 24.)

Cost Per Square Foot ($)		
Building Configuration		
Basic (a)	Corner (b)	L-Shaped (c)
20.30	26.10	30.00

(a) Building #2
(b) Building #3
(c) Building #5

Table 24
Cost as a Function of
Building Configuration:
Steel Solution, Level 2

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[5] This cost is based on bracing on four sides, if only the two open sides are braced, the cost can be reduced $4.00 per square foot.

Buildings with small square footprints may be more expensive to retrofit on a square foot basis than larger buildings because smaller buildings have a higher wall to floor area ratio. In other words, the same amount of floor area in a small building is associated with more wall area, and the wall is the part of the building likely to require the most seismic upgrading. Further, buildings with fewer rooms generally have a higher cost per room. This is for the above reason, as well as the fact that in renovation projects there is a cost associated with all projects regardless of size, and the more rooms that a building has, the smaller the cost will be per room.

Comparison with Other Studies and Real Construction Data

To further evaluate the data accumulated from the work-shop, the post-workshop cost estimates were compared to other studies and actual construction data. The primary source of comparable data is associated with seismic retrofit ordinances that have been enacted in the Los Angeles area. In general, these studies and actual construction data show lower costs for seismic upgrading work than do the workshop estimates. This is due to a number of factors, including 1.) the use of pre-1986 dollars; 2.) lack of accounting for architectural and other associated costs; 3.) different building characteristics in Los Angeles (e.g., buildings not built to property lines are generally less expensive to retrofit); 4.) the upgrading techniques accepted in Los Angeles (e.g., interior partitions are allowable for shear resistance); and 5.) the use of "worst case" scenarios for the workshop.

Brief descriptions of the four studies/data sets used for comparison follow:

- Wheeler & Gray Consulting Engineers performed one cost study in May of 1980, before the implementation of the City of Los Angeles' Seismic Upgrading Ordinance. From the buildings studied, the average structural cost was reported to be, in April 1980 dollars, $7.87 per square foot. This cost does not include architectural demolition and refinish. Thus the reported cost of $7.87 per square foot is quite low. (See Table 25.)

- Raymond Steinberg & Associates conducted a cost study again in the Los Angeles area in 1983 based on the same standards. Based on 15 buildings reported, the average structural cost, omitting extreme values, is approximately $7.50 per square foot. Again it must be emphasized that this cost is based on pre-1983 dollars and does not include architectural items. (See Table 26.)

- According to Christine Platt & Robin Shepherd, in their 1985 article "Some Cost Considerations of Seismic Strengthening of Pre-code Buildings," the average unit cost for seismic upgrading in Long Beach is reported to be approximately $15 per square foot. Long Beach's ordinance is more stringent, correlating with strengthening level 2 of the post-workshop cost study.

- The City of Los Angeles, Housing Division, Community Development Department reported costs for seismic retrofit to be approximately $7.00 per square foot. this is an average value of 21 buildings during or before 1986. Again architectural items are not included in this figure. (See Table 27.)

In comparison with this cost analysis, the data from the Los Angeles sources is low. This discrepancy is partly due to the method of strengthening. Since the Los Angeles ordinance allows shear resistance values for existing interior partitions and allows new plywood partitions to be used for shear walls, the cost of the transverse and longitudinal bracing is substantially reduced. In addition, because partitions are used for shear resistance, diaphragm strengthening can also be reduced. In total, this can reduce the structural cost up to $6.00 per square foot. Under most other seismic retrofit ordinances, the above strengthening method is not allowed. The Long Beach ordinance is typical and their average cost of $15 per square foot compares favorably with this cost analysis.

As a whole, this cost study is a slightly high estimate of the average case seismic strengthening cost. This is mainly due to the fact that the costs are based on buildings with poor existing conditions. For example, this study assumes the existing diaphragm to be a straight sheathing, the worst possible case. The resulting estimate is therefore conservative, the actual average cost. May be $2-$3 per square foot less. The cost is also based on conservative engineering design which provides for necessary strengthening work not specifically required by code, such as bracing the building against torsional effects and providing a seismic separation for L-shaped buildings, etc. Thus, the costs presented are based on code intention rather than code minimum.

Description	No. of Stories	Construction Cost[a] Total	Construction Cost[a] Per Sq.Ft.	Project Cost[b] Total	Project Cost[b] Per Sq.Ft.
Apartment 33,4000 Sq. Ft.	4	$190,000	$5.67	$208,000	$6.22
Apartment and Industrial 17,2000 Sq. Ft.	3	$189,000	$11.02	$207,000	$12.08
Warehouse 6,4000 Sq. Ft.	1	$50,400	$7.90	$55,600	$8.70
Industrial	1 + mez.	$78,300	$7.15	$86,500	$10.60
Commercial	2	$135,000	$9.66	$148,000	$10.60
Average		$129,000	$7.87	$141,000	$8.60

Note: [a] Includes Contractor's Profit, Overhead and other contingencies.
[b] Includes Engineering, Testing and Building Permit Fees. (based on April 1980 dollars from Wheeler and Gray report.

Table 25
Summary of Wheeler and Gray Cost Study*

*Base on Wheeler and Gray, Consulting Engineers, Cost Study Report for Structural Strengthening Using Proposed Division 68 Standards, Los Angeles City Council Action C. F. No. 79-4244, May 1980, in an article by Christing M. Platt and Robin Shepherd, "Some Cost Considerations of the Seismic Strengtheing of Pre-Code Buildings," "EERI Earthquake Spectra Magazine, Vol. 1, No. 4 Aug. 1985, page 699.

Building Address	Building Size (Sq.Ft.)	Number of Stories	Total Cost (Dollars)	Unit Cost ($/Sq.Ft.)	Notes
3923 W. 6th St.	31,400	4	$219,800	7.00	a
108-116 N. San Pedro	30,830	3	$107,450	3.47*	b,c
3745 Grand	21,600	4	$151,200	7.00	d
331-355 E. First St.	15,450	3	$112,100	7.26	b
1475 W. Adams	15,000	3	$103,950	6.93	
325-329 E. First St.	14,100	3	$105,800	7.50	b
341-345 E. First St.	13,790	4	$97,000	7.03	b
6379 Van Nuys Blvd.	12,000	2	$62,040	5.17	
347-353 First St.	11,407	3	$102,000	8.94	b,e
8560-3566 W. Pico	10,450	1	$51,940	4.97*	f
321-323 First St.	9,810	2	$90,000	9.17	b
309-313 First St.	9,035	2	$76,100	8.42	b
337-339 E. First St.	8,100	2	$90,000	11.11	b
303-307 E. First St.	3,250	1	27,000	8.44	b
106 N. San Pedro	1,872	1	$47,00	25.50*	b
	SUM = 208,194		SUM $1,444,080	7.0 = AVERAGE	

Table 26
Los Angeles Seismic Stregnthening Cost Study
(Raymond E. Steinberg)

Notes:
- a. Long, narrow four story office building which required no interior plywood shear walls.
- b. Community Redevelopment Agency (CRA) study with no plans drawn or bids taken.
- c. Large, regularly-shaped building with many existing interior partitions.
- d. Contact was not awarded but estimate was based upon bids.
- e. Height/thickness ratio of walls at top floor was excessive and wall required bracing. There was also illegal addition at the rear.
- f. Owner was contractor for a portion of the work.

Based on Steinberg, R., Typical Cost Data for Compliance with Division 68, SEAOSC Seminar Notes, March 8, 1983, in Platt and Shepherd, ibid, p. 698.

Project Number	Total Sq.Ft.	Total Units	Total Rehab Value	Seismic Cost	Seismic Cost/Sqft	Other Rehab Cost	Total Cost/Sqft
1/2.	------	71	1,800,000	600,000		1,200,000	
3.	------	74	1,015,000	324,000		691,000	
4.	------	59	292,752	413,000		(120,248)	
5.	38,353	68	912,234	346,360	9.03	565,874	23.79
6.	------	40	857,940	325,745		532,195	
7.	------	59	746,830	191,970		554,860	
8.	28,280	44	568,080	91,200	3.22	476,880	20.09
9.	------	48	610,560	145,000		402,980	
10.	28,212	40	508,800	103,160	3.66	349,140	18.03
11/12.	64,081	71	1,018,201	231,290	3.61	686,261	15.89
13.	26,600	48	891,000	131,619	4.95	759,381	33.50
14.	21,750	47	1,089,000	203,934	9.38	885,006	50.07
15.	23,000	48	777,000	130,447	5.67	646,553	33.78
16.	22,800	40	775,000	126,478	5.55	648,522	33.99
17.	18,640	32	578,000	114,746	6.16	463,256	31.01
18.	------	18	267,000	87,886		179,114	
19.	26,168	47	650,000	172,000	6.57	478,000	24.84
20.	28,472	48	438,000	203,000	7.13	235,000	15.38
21.	21,680	32	474,000	137,000	6.32	337,000	21.86
22.	40,800	71	640,000	369,590	9.06	270,410	15.69
23.	26,531	41	627,000	212,500	8.01	414,500	23.63
24.	15,735	27	406,000	116,902	7.43	289,098	25.80
25.	16,254	12	185,725	139,395	8.58	46,330	11.43
26.	20,640	32	300,000	152,200	7.37	147,800	14.53
27.	20,106	28	398,396	216,096	10.75	182,300	19.81

Table 27
Housing Division Community Development Department
City of Los Angeles

December 1986

Summary of Cost for Rehabilitation
of Seismic Deficient Buildings
Assisted by City Funding

CHAPTER IV. THE CHOICE OF ACCEPTABLE SEISMIC RISK: COSTS, ENGINEERING, AND LIFE SAFETY

INTRODUCTION: RISK AND UNCERTAINTY

In this section we address the question that haunts policy-makers, particularly responsible elected officials, when faced with the necessity of making decisions about life safety: how much safety should be mandated? The level of risk that is politically responsible and socially acceptable will depend on a number of factors including the nature of the risk, direct and indirect costs of reducing risk, the size and characteristics of the exposed population, and whether an individual's exposure is voluntary or involuntary.

Seismic safety decisions are further complicated by a high degree of uncertainty: we cannot state with certainty what the likelihood of a moderate or major earthquake in San Francisco is in a given year. Nor can we predict what the ground motion or peak acceleration of any such event would be. Moreover, with respect to URM housing, a great deal of uncertainty exists as to the effectiveness of various building systems in different kinds of earthquakes. Finally, even if we did know how specific building systems would respond in an earthquake, we would not be able to predict how many deaths or injuries would result from those responses.

PROBLEM STATEMENT -- URM RESIDENTIAL BUILDINGS IN SAN FRANCISCO

The City's hazardous buildings inventory reveals that there are approximately 10,280 residential hotel rooms, 5,138 tourist hotel rooms, and 10,043 apartments in unreinforced masonry buildings in San Francisco. The great majority of these buildings are in Chinatown, the Tenderloin, and the Bush Street corridor, neighborhoods housing many of the City's lowest income households. Moreover, URM buildings comprise a high percentage of the lowest-income housing stock in those neighborhoods. For example, approximately 70% of the SRO hotel units in Chinatown are in URM buildings.

Experience demonstrates that these pre-code URM buildings cannot withstand the grounds shaking associated with even a moderate earthquake. These buildings have a relatively high likelihood of being seriously damaged in an earthquake, and, more significantly, are likely to collapse, posing a substantial risk of death and injury to occupants and others.

Our engineering and cost estimating study considers a range of upgrading options, from the minimal acceptable level to much higher levels of intervention. For the most typical building, costs for these various levels of upgrading range as follows:

minimal acceptable upgrade: $6-10/s.f.

Level 1 upgrade (equal to the Los Angeles Class III and IV requirements: $16-21/s.f.

Level 2 upgrade (equal to the Los Angeles Class II requirements): $21-26/s.f.

It should be noted that additional architectural and cosmetic work associated with seismic upgrading could easily add another $20 to $30 per square foot (or approximately $8,000 per unit) to the cost of seismic rehabilitation.[1]

Seismic upgrading expenses of this magnitude raise a number of serious policy questions. The three most significant policy clusters are mentioned here:

Effect on tenants: The most immediate concern is the likely effect of such imposed costs on tenants in low and moderate income units. If costs are passed through, can the tenants afford to pay the increased rents necessary to amortize an expense of $2,000 to $10,000 per unit? Will demolition lead to significant displacement? Both temporary relocation (during renovation) and permanent relocation assistance must be considered.

Concern is also focused on landlords: Is it fair to require the owners of low and moderate income housing to bear the burden of bringing previously lawful structures up to presentday, rigorous standards? If rent pass-throughs are prohibited or limited, and buildings become uneconomic due to the expense of upgrading, will landlords be required to provide housing at a financial loss, or will they be permitted to demolish substandard buildings, taking them out of the rental market altogether? Can subsidies or cost savings be found to mitigate the effects of upgrading on building owners?

What level of upgrading: Finally, regardless of who bears the cost, is the increase in safety associated with "complete" (i.e., up to current code) upgrading worth the cost, either in an absolute sense, or relative to other potential expenditures on public safety or housing? Considering the multiple layers of uncertainty associated with seismic risks, is it possible to make rational decisions with respect to upgrading requirements?

SEISMIC RISK ASSESSMENTS

There is a rich body of literature on public policy approaches to risk management, including risks arising from natural disasters. The key point is that risk reduction, however measured, is not free; decision makers must weigh a variety of policy objectives when determining the degree of risk reduction that should be mandated. It is useful to consider three of these general risk assessment approaches to the seismic retrofit problem.

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[1] In the Los Angeles ordinance, buildings with fewer than 100 occupants are categorized Class III and IV, while "high risk" Class II buildings are those with over 100 occupants.

Building hazard indexes - This approach, implemented in Long Beach as the "balanced risk concept,"[2] begins with the adoption of a socially acceptable level for the risk of death due to earthquakes, and then derives building standards that will impose that level of risk on building occupants over the life of the building. The "acceptable" level of risk was determined by the City Council to be one death per one million people exposed per year to existing buildings. Use of a constant risk factor means that buildings with longer life spans and with larger numbers of occupants must be upgraded to higher standards than other buildings.

Cost-benefit and Cost-effectiveness studies - The balanced risk concept described above does not weigh the costs and benefits of upgrading existing buildings, or any particular existing building. Many analysts have argued that this type of approach is an inefficient use of society's resources. Many have argued that the optimum level of building safety must be derived from weighing the costs and benefits of safety improvements, and only requiring those improvements for which benefits, measured in dollars, exceed costs. Since the costs and benefits of upgrading different buildings will vary, these analysts consider the determination of a pre-set, acceptable risk of death for all buildings to be arbitrary and inefficient. Instead, upgrading options must be considered separately for each building, and no particular improvement should be re-quired unless it returns net benefits to society.

One problem with using cost-benefit analysis in the life safety arena, however, is that to measure upgrading costs against lives saved, it is necessary to determine the dollar value of a life saved in a future earthquake. As discussed below, the value of even a "statistical life" is extremely difficult to determine, and is essentially an arbitrary judgment by the decision-maker. For this reason, analysts prefer cost-effectiveness evaluations, rank- ordering potential upgrading options according to their cost in dollars spent per life saved.

For example, in a study on upgrading of existing unreinforced masonry buildings in Boston, the author demonstrates that the cost per life saved, would increase by a factor of ten (from $240,000 to $2,560,000) between a minimal policy of tying floors and walls together, and a more stringent requirement to add interior shear walls. This cost escalation is due in large part to the fact that over a 50 year period the number of lives saved by the minimal upgrade policy would be 37, while more stringent requirements would only increase the number of lives saved to 41.[3]

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[2] John Wiggins, "The Balanced Risk Concept: new approach to earthquake building codes," Civil Engineering August 1972, pp. 55-59.

[3] A number of very thorough analyses of this sort have been done by Elisabeth Pate-Cornell. See, e.g., "Costs and Benefits of Seismic Upgrading of Some Buildings in the Boston Area," Earthquake Spectra Vol. 1, No. 4, August 1985.

In other words, once minimal improvements were made, a 10% increase in lives saved would require a 1000% increase in costs. In another study, the same analyst calculated that in the San Francisco Bay Area, it would cost $6 million per life saved to implement the 1973 UBC for new buildings, and $22 million per live saved to upgrade existing buildings to this standard[4]. This study did not, however, evaluate the costs of benefits associated with upgrading existing buildings to standards less demanding than the 1973 UBC.

The final step in cost-effectiveness decisions is to fix the balance point, the point at which the costs of increased safety are found to exceed its benefits. Decision-makers using cost-effectiveness analysis for seismic risk management must therefore make a policy determination as to the value of a life saved in order to fix upon the appropriate level of life safety to mandate.

There are many ways to determine the value of a life saved, including the projected earnings approach, average jury awards in wrongful death cases, risk premiums for hazards employment, and public expenditures on life safety. These are discussed in the next section.

Comparative social risks - A more far-reaching approach to life safety compares seismic risks to other forms of risk in society. There are two reasons to perform this analysis. First, knowledge of what risks are generally accepted in society may guide the decision-maker in determining what level of life safety to mandate in the construction and rehabilitation of buildings. Second, if cost-effectiveness curves could be produced for a variety of social investments in different fields of life safety, it would be possible to compare investments in seismic upgrading to, say, investments in fire code enforcement or traffic safety improvements.[5] Decision-makers considering a seismic safety ordinance must consider that ever-increasing levels of seismic safety may detract resources from other, more effective investments in life safety. The relative nature of "acceptable risk" is acknowledged by the Building Seismic Safety Council, an independent, voluntary body established under the auspices of the National Institute of Building Sciences. The council defines acceptable risk as:

> a probability of social or economic consequences due to earthquakes that is low enough (for example in comparison with other natural or

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[4] Pate', M.E., "Acceptance of a Social Cost for Human Safety: A Normative Approach," Proceedings of the 2nd U.S. National Conference on Earthquake Engineering (Stanford University, 1979.)

[5] This approach is set out generally in Chauncey Starr, "Social Benefit Versus Technological Risk," Science Vol. 165, 19 September 1969, and David Okrent, "Comment on Societal Risk," Science Vol. 208, 25 April 1980. The topic is explored with particular reference to seismic risk in G. Grandori and D. Benedetti, "On the Choice of the Acceptable Seismic Risk," Earthquake Engineering and Structural Dynamics Vol. 2 (1973).

man-made risks) to be judged by appropriate authorities to represent a realistic basis for determining design requirements for engineered structures, or for taking certain social or economic actions.

Such a definition, by itself, does not offer much guidance to decision-makers beyond the suggestion that seismic risks are acceptable if they are comparable to other accepted risks in society. Evidence suggests that socially accepted risks vary quite significantly across a wide range of activities. Chauncey Starr calculated the risk of death resulting from exposure to or participating in a number of activities, including automobile travel, airline travel, smoking, use of firearms, and skiing and compared to them the "background" levels of risk associated with disease and natural disasters. In general, he discovered that the public is willing to accept "voluntary" risks (e.g., risk of death from smoking) roughly 1000 times greater than "involuntary" risks (e.g., risk of death due to natural disasters or the use of electric power). He concluded that "we are loathe to let others do unto us what we happily do to ourselves."[6] As another researcher concluded, "society uses the word safe in a vague and 'inconsistent' fashion."[7]

However inconsistent apparently acceptable risks may be across various types of activities, comparative risk analyses do support two useful conclusions. The first is that society obviously finds some risks "acceptable," depending on the type of exposure, the benefits of the activity involved, the cost of greater safety, and other factors. We do not pursue zero-risk solutions and in fact face and accept significant risks on a daily basis. The second conclusion is that (other factors, such as distributional equity, being equal) risk-reduction investments should be made so as to maximize the total lives saved in all exposure categories. By this logic it would be socially inefficient to spend $800,000 to save a life through, say, improvements in bridge design if lives could be saved for only $300,000 through better enforcement of fire codes.

Despite the logic of the "least-cost investment" principle just described, public and private decisions establishing the value of life safety vary to a remarkable degree. One study of wage differentials in high-risk occupations suggested that the labor market values risk reduction at about $340,000 (in 1981 dollars) per life saved.[8] Another occupational study for more typical job risks established $1,000,000 per live saved as the appropriate figure.[9] The Nuclear Regulatory Commission's standards for occupational exposure to radiation, in contrast, required investments of up to $1,000 per manrem of exposure reduction, which yielded a value of $5,000,000 (in 1975 dollars) per premature death deferred.[10]

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[6] Starr, op. cit., p. 1235.

[7] Okrent, op. cit., p. 372.

[8] Thaler, R. and S. Rosen, "The Value of Saving a Life: Evidence From the Labor Market," in D.E. Terleckys (ed.), Household Production and Consumption, New York: Columbia University Press (1975). pp. 265-297.

A great deal of attention has been given to this issue in the area of transportation safety, and here as well one sees a wide range of investments per life saved. David Okrent reports that the French government spent approximately $30,000 per life saved through road accident prevention, but $1,000,000 per life saved through aviation accident prevention.[11] The National Academy of Sciences reported that $200,000 per life saved (in 1975 dollars) was a general bench-mark for evaluating the efficiency of investments in such features as extra lanes, highway dividers, and improved guardrails.[12] Other transportation analyst used $300,000 in the same time period. One study of seatbelt use suggests that automobile users value a saved life at $260,000.[13] While figures noted here cover a wide range, they may nevertheless be helpful in a general way to decision-makers considering investments in seismic risk reduction. However it must be noted that explicit comparisons are not possible in the present study since we have not attempted to estimate the statistical likelihood of deaths due to the collapse of URM buildings in San Francisco, either with or without implementation of a mandatory retrofit ordinance.

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[9] See William Schulze, et al, "An Economic Analysis of the Benefits and Costs of Seismic Building Codes," Proceedings of Earthquakes and Earthquake Engineering (September 1981).

[10] Okrent, op. cit. at 374.

[11] Id.

[12] J. Linnerooth, "The Evaluation of Life Saving: A Survey," IIASA (1975).

[13] G. Blomquist, "Value of Life" Implications of Automobile Seat Belt Use," (1977).

POLICY OPTIONS FOR SAN FRANCISCO

Although the three approaches to seismic risk assessment noted above are quite different, they all represent factors that decision-makers should take into account in forming a seismic rehabilitation policy. Other factors being equal, buildings with larger numbers of occupants should be upgraded more rapidly and to higher standards than other buildings. At the same time, choices among design standards should be based on careful weighing of their costs and benefits. Finally, decision-makers must weight investments in seismic safety against investments in other life safety areas in order to select the most appropriate level of seismic safety to seek.

Three important characteristics of this situation are noted below:

1. Retrofit standards may logically differ from standards for new construction.

When first confronting the retrofit problem, most decision-makers will assume that the standards for new construction are also appropriate requirements for renovation. This is not necessarily so, even though less stringent standards appear discriminatory, imposing (depending on one's point of view) higher costs on new builders, or higher risks on tenants of older buildings. To begin with, it is helpful to consider that existing buildings vary widely in their seismic risk characteristics, depending on site, design, building materials, the code in effect at the time of construction, and the quality of building maintenance. Establishing moderate retrofit standards for older buildings does not create a "two class" safety system; it improves the position of pre-code buildings along a continuum. State legislation (S.B. 445, enacted 1979) recognizes this reality, enabling local governments to impose lower standards for reconstruction of existing hazards than for new construction. The City of Santa Ana adopted a moderate retrofit ordinance for pre-code buildings in 1980, estimating that the standard of rehabilitation required for pre-1934 buildings would bring them to a level of life safety comparable to the code levels in effect in the 1940's.

Different standards are also logical on a cost-benefit basis, since it costs more to retrofit to the clrrent standards than it does to meet those standards in new construction. Moreover, the distribution of costs and benefits is not symmetrical. Building new construction to tougher codes imposes costs chiefly on middle to upper-income tenants and buyers, while upgrading older buildings imposes costs chiefly on moderate and lower-income tenants and their landlords.

2. As risk is reduced, cost rises exponentially.

Seismic upgrading resembles other arenas of risk reduction in that the cost of risk reduction rises exponentially as greater and greater degrees of safety are reached. Generally speaking, the risks associated with building failure are deaths, injuries, and structural damage (property losses). Because individual buildings and site characteristics are so variable, and earthquake characteristics are unpredictable, it can never be known with certainty just what risks are associated with a given building standard. However, it will be much more expensive to upgrade buildings to protect against the risk of structural damage than it will to protect "life safety" only.

Moreover engineering research consistently suggests that the cheapest, most dramatic improvement in seismic life safety in URM buildings can be obtained simply by anchoring the walls of the building to the floors and ceilings. Beyond this initial step, marginal improvements in life safety and associated protections against property damage are increasingly expensive. The benefits of particular improvements are more difficult to quantify than the costs, but it is quite possible that one would obtain as much as a 50% reduction in injuries and lives lost in URM buildings for the first 10% of the cost necessary to bring the buildings up to current code. (Santa Ana expects an 80% reduction for in the risk of death or serious injury costs of $6 to $7 per square foot.)

3. The city may consider a wide range of implementation strategies in addressing the problem of existing URM residential structures.

In preparing this report, we have evaluated a wide range of implementation strategies potentially available to the City in addressing the residential URM problem. Some of these strategies are discussed below.

Do nothing. A seismic upgrading program will be expensive, disruptive, and could displace a large number of low and moderate income tenants. In the absence of a program, the number of URM residential buildings will gradually decrease, and (barring a damaging quake) the prob-lem will diminish. There may be resources (for example, federal grants) for upgrading in the future that do not exist today. Of course, in the meanwhile, thousands of City residents are exposed to significant risk of death or injury in the event of a damaging earthquake.

Information only. The City can attempt to influence the housing market, creating incentives for voluntary upgrading, and warning tenants of their risks by giving public notice of the structural seismic risk of individual buildings. This notice could be posted prominently on the face of the building, or could be placed in the land records, or both. (A proposal for posting notices was aggressively opposed and defeated by building owners in Los Angeles; Palo Alto currently places some seismic safety notices in the land records.) However, since low income tenants have limited discretionary income, it is unlikely that they will be able to bargain effectively for improved safety, so it is not clear what good would be accomplished by providing such a notice in San Francisco.

City-initiated condemnation. An ordinance might declare that pre-code URM buildings may be declared a public nuisance, and after suitable notice and hearings, could be abated by demolition at the owner's expense. An owner could escape demolition only by upgrading to specified standards. This procedure puts a heavy procedural burden on the City, and is unlikely to result in much rapid action. It could also cause the loss of a large portion of the low income housing stock.

Immediate upgrade v. phased compliance. An ordinance might establish a fairly rapid schedule for compliance with specified, final standards, following notice to affected building owners based on the City's inventory. Alternatively, the ordinance might require the upgrading of affected structures in stages. For example, owners might be required to install wall anchors within 12 months, but be given 3 or more years to come up to higher, final standards. The Los Angeles ordinance gives owners a choice among three options: total compliance, anchors first, or demolition. Under the total compliance option, seismic upgrading is done all at one time, and must be completed within three years of receipt of notice from the city. Or, an owner may choose to proceed in stages, installing anchors within one year and completing the rest of the work within 4 to 10 years, depending on the hazard classification of the building. Finally, the owner may demolish the structure instead of upgrading it. Experience in Los Angeles suggests that this form of phased compliance is not very successful. However, we believe a phased program is necessary in San Francisco, but it must be properly managed.

All buildings alike v. hazard index overlay. The techniques described above could be applied to all URM residential buildings equally, or they could be applied to buildings according to a specified hazards index. The Los Angeles, Santa Ana, and Long Beach ordinances all adopt the hazards index approach: buildings with larger numbers of occupants are required to upgrade more rapidly and are required to meet higher design standards. This is a useful concept when comparing categories of greatly dissimilar buildings -- e.g., hospitals and auditoriums vs. duplexes. However, most URM residential structures in San Francisco are of the same general size and population exposure characteristics, so a hazard index overlay would probably not be very useful.

CONCLUSION: DESIGNING A SEISMIC UPGRADING PROGRAM

As the preceding discussion indicates, public decision-makers make risk-benefit decisions, either implicitly or explicitly, whenever determining an acceptable level of seismic safety. A "non-decision" is of course a decision on this point as well. Considering the high levels of uncertainty involved in seismic predictions, and the importance of value judgments in life safety decisions, public policy decisions in this realm are unlikely to satisfy cost-benefit purists. To design a workable public program decision-makers must consider several criteria:

Equity: Seismic risks and regulatory burdens are now distributed unequally throughout San Francisco; any URM retrofit program will alter this distribution, but the burdens and benefits of any program will also be distributed unequally. As noted above, program design must be sensitive to impacts on tenants, owners, and taxpayers alike. In particular, it is important to weigh seismic risks, tenant displacement and community disruption, not just monetary costs, when evaluating the fairness of any proposed program.

Cost-effectiveness: Since funds, both public and private, for seismic upgrading are limited, a retrofit program must be designed to apply those funds in the most effective manner possible. For most buildings, the greatest improvements in life safety per dollar spent will be achieved through moderate rather than total upgrading investments.

Comparability: Decision-makers must evaluate the benefits of investments in seismic upgrading, compared with investments in other life safety improvements. This does not mean that seismic upgrading should be abandoned if other more cost-effective investments are theoretically possible, since those other options may be politically or administratively unavailable. They also involve different equity considerations. Nevertheless, among equally available alternatives, comparability of costs and benefits must be considered carefully.

Financial feasibility: Many otherwise desirable public programs remain unimplemented because the funds are unavailable to accomplish them. It is clearly impossible to finance a seismic upgrading program solely from public funds. Financial analysis of upgrading options (detailed elsewhere in this report reveals that upgrading requirements will have to be limited to be feasible at all, and that a broad mix of financing strategies will have to be employed.

Administrability: Implementing a seismic upgrading program that respects the criteria listed above is a complex administrative task. Public administrative costs can be lowered, but usually at the cost of higher private costs and more tenant and community disruption. No program will work if it cannot be administered effectively and sensitively. Program design must reflect this reality.

In sum, the design of a seismic upgrading program is a challenging task, requiring the joint consideration of a number of factors by responsible policy-makers. In this report we have not attempted todesign such a program. We have however, considered the criteria noted above, along with the economic and engineering data developed in this study. Broad proposals and recommendations based upon this analysis are set out in the next chapter.

CHAPTER V. SUMMARY OF RECOMMENDATIONS

The thrust of this study has been to bring together concerns for life safety regarding seismic hazards in existing unreinforced masonry buildings, with strong concerns for the protection of San Francisco's low-income housing. Because the majority of San Francisco's unreinforced masonry residential buildings are located in Chinatown, the Tenderloin, and the Bush Street corridor, neighborhoods which house the city's lowest-income populations, the situation is particularly problematic. Before making our recommendations for policies for improving the buildings with minimal disruption to the community, it would be useful to describe the impact a seismic ordinance has had on housing in Los Angeles.

LOS ANGELES COMPARISON

Although several California cities have enacted seismic regulations for existing buildings, Los Angeles is the only such city with a significant number of URM residential buildings in downtown neighborhoods. The Los Angeles "Earthquake Hazards Reduction Ordinance" was enacted in February 1981. The ordinance provides two alternatives for bringing a building up to code: Alternate I allows an owner three years to bring the property to full compliance. Alternate II allows the owner to perform the work in two phases. The first phase requires the owner to install wall anchors at the roof and floor lines within one year. The second phase requires completion of the remaining work necessary for full compliance in three to seven years.

The Department of Building and Safety determined that there were 7,792 buildings subject to the ordinance and developed a 15 year program to cite approximately 2,000 essential and high risk buildings within the first four years after the ordinance was enacted. The remaining 6,000 buildings were to be cited in succeeding years. Building and Safety (B&S) was scheduled to begin citation of residential (medium risk) buildings in 1985. In September of that year, in reaction to the Mexico City earthquake, the City Council amended the ordinance to accelerate compliance. All remaining buildings were to be cited within 18 months and owners would have no more than 3 years to achieve full compliance.

This meant that approximately 1,400 residential buildings containing 34,000 housing units have been or soon will be put on notice. Although the process of rehabilitation has begun on only about 2,000 units, estimates are that at least 1,200 people have been evicted so far.

The Community Development Department (CDD) and the Community Redevelopment Agency (CRA) have allocated resources for solving seismic safety problems. These agencies, along with CDD's Rent Stabilization Division, were the first to recognize the unforeseen effects of the Earthquake Hazards Reduction Ordinance.

CRA has assisted in funding the upgrading of 201 units while CDD has assisted 1,733 units in 39 buildings, using a combination of funding sources (Community Development Block Grant CCDBG, HUD 312, HUD Rental Rehabilitation, Tax Exempt Bonds, Owner Cash and private lenders). From this experience they have found the average costs per unit to be $3 - 5,000 per unit for full seismic compliance[1] and $1,000 per unit for anchoring walls and floors. In addition, many owners have opted to combine earthquake rehabilitation with substantial code and cosmetic renovations[2]. The average cost per unit for these improvements has been $1,000 per unit for fire safety compliance and $8,000 per unit for other rehabilitation[3].

The result, under current city law, is that the buildings renovated with assistance from city funds are being taken out of rent control and can command rent increases of as much as $250 per month per apartment[4]. While some buildings can command higher rents, and the city can provide some Section 8 rental assistance to some tenants, many buildings are economically marginal, and these units represent a housing resource that is almost exclusively utilized by low income tenants, including a high percentage of senior citizens on fixed incomes. It is feared that these tenants will be displaced either by steeply escalated rents or by demolition of these units because the cost of the work required outweighs the income-producing capacity of the building.

An added misfortune for tenants is that it is very difficult and inefficient to do the renovation work with the tenants in place. And yet if major rehabilitation work involves seismic upgrading, landlords are exempt from paying relocation assistance. If earthquake repairs were not involved owners would have to pay evicted tenants up to $2,500 to move.

It is not fair to label landlords as the "bad buys" in this situation since they are bearing the brunt of the cost of seismic repair. When the ordinance was passed, city officials assumed more state and federal aid would be available. Further, renovation costs have been higher than originally anticipated, and the new tax reform law provides fewer incentives for real estate investments.

In November of 1986 the Community Development Department recommended to the Governmental Operations Committee[5] and to the City Council that a six month moratorium on evictions for seismic rehabilitation be enacted in order to analyze alternatives that would mitigate the impact on the housing stock, owners, and residents. At the time of this writing, no decision as been reached, but the Council is considering the issue.

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[1] In Los Angeles full code compliance is equivalent to level 1 in this study.

[2] In most cases, federal funds will require that all building code violations be corrected, and private lenders want to see cosmetic improvements in order justify the increase in building value the rehabilitation loan represents.

[3] Department heads are more comfortable with average costs per unit than costs per square foot because of tremendous variations building by building; however, CDD has stated that rough square footage costs are approximately $10/s.f. for seismic and $30/s.f. for total rehabilitation.

[4] The city average for rehabilitated units has been over $200 per month.

IMPLICATIONS FOR SAN FRANCISCO

There are a great many similarities between Los Angeles and the San Francisco circumstances. The majority (70%) of San Francisco's 20,000 residential units and 5,000 "tourist" hotel units are in Chinatown, the Tenderloin, and the Bush Street Corridor, where the population is predominantly low-income with a high percentage of senior citizens. Like Los Angeles, some buildings (particularly in the Bush Street area and outer edges of the Tenderloin) would be prime candidates for rehabilitation and gentrification. Also like Los Angeles many Chinatown and Tenderloin buildings are economically marginal. For these buildings a seismic ordinance poses a threat to building owners as well as tenants.

Unlike Los Angeles, San Francisco has the additional problem that one neighborhood, Chinatown, has been and continues to be valued as a unique historic and cultural setting. As such, decisions that affect the physical fabric of this neighborhood must be carefully considered. San Francisco also has a much lower vacancy rate than Los Angeles. There are very few housing options for Chinatown and Tenderloin residents.

Further, building costs are much higher in San Francisco than Los Angeles. The average cost per room for seismic upgrade is $4,000 - $6,000 in San Francisco as compared to $3,000 - $5,000 in Los Angeles. This is because labor costs are generally higher in San Francisco and construction is more difficult when buildings are built out to the lot line and bearing walls are adjacent.

Thus we can assume that total rehabilitation costs in San Francisco under a Los Angeles-style ordinance would be well in excess of $10,000 per unit, because owners would want to make other building repairs at the same time that seismic work was undertaken. Essentially this implies that San Francisco would face all of the same problems that Los Angeles is currently experiencing: financing the rehabilitation, relocation of tenants lost housing units and increased rents.

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[5] The information in this section is based on a report to the Government Operations Committee by Douglas S. Ford, General Manager, Community Development Department Rent Stabilization Division, City of Los Angeles, "Seismic Safety Impacts and Issues on Residential Rental Housing," Nov. 13, 1986; a newspaper article by Penelope McMillan, "Standards Put Units Beyond Poor's Reach," ?Los Angeles Times? Nov. 23, 1986; testimony at the State Seismic Safety Commission in Sacramento, Ca. by Craig Avery, Director of Housing for the Community Development Department, City of Los Angeles; and site visits and interviews by Principal Investigator, Mary Comerio.

RECOMMENDATIONS

The data analysis developed in this study parallel, to a substantial degree, the conclusions developed from experience in implementing the Los Angeles ordinance, and the recommendations proposed here draw on both sources. A key lesson is the conclusion that an engineering-only approach to this issue cannot succeed. It will be necessary to develop and implement a package of regulatory and funding mechanisms to meet the goals of the city, neighborhood groups, building owners, and tenants.

In brief, we recommend that the city enact a seismic rehabilitation ordinance that requires owners to complete a basic minimum upgrade as appropriate for each building. For most buildings, this means installation of shear bolts and wall anchors; additional bracing may be required as a minimum for particular buildings. In order to protect the low income housing stock and the rights of tenants, the seismic ordinance must contain provisions to discourage demolition of URM buildings unless replacement housing is provided. The ordinance must also be crafted to work with the city's rent control ordinance to ensure adequate relocation assistance and to control rent increase pass-throughs. The city must seek adequate funding to assist owners in upgrading. Finally, the city should carefully manage and phase implementation of a seismic rehabilitation program in order to minimize its impacts on tenants, owners, and low-income housing opportunities.

These recommendations are set out in more detail in the sections below.

Engineering Requirements

As detailed at length in this report, complete seismic upgrading to current code requirements is neither cost effective nor socially desirable in San Francisco. We recommend that the city enact a seismic upgrading ordinance for pre-code URM buildings, containing the following elements:

- Pre-code URM buildings must be upgraded, at a minimum, with a shear bolt and wall anchor system.

- In addition, each building must be evaluated and must meet minimum engineering standards with regard to three especially vulnerable features: torsional problems, vertical discontinuity, and long diaphragm span.

- The city's code for these measures should be modeled on the Uniform Code for Building Conservation, which acknowledges and accepts unique existing building conditions and relies on "sound engineering judgment" to devise appropriate measures to increase building safety.

- Finally, the city's ordinance should provide that compliance with seismic upgrade requirements does not force full compliance with all other elements of the building code.

Demolition Controls

One of the chief concerns with the implementation of an upgrading ordinance is the fear that it will lead to demolition of existing, scarce affordable housing. Some owners are already anxious to convert their properties to commercial use; others will find the cost and problems of upgrading prohibitive.

Experience in Los Angeles is not reassuring. As of July 1986, owners had demolished approximately 600 commercial buildings (10% of the commercial buildings cited for upgrading). The impact on the residential stock may be much greater, despite the city's concerted effort to provide funding for seismic rehabilitation. Los Angeles has only recently begun to cite residential buildings, but the Building and Safety Department estimates that 346 buildings have been or shortly will be demolished, instead of being upgraded. Although the city has already provided over $20 million in financial assistance to building owners, this money has resulted in renovation of only 39 buildings or 1,733 of their 34,000 residential units affected.

Any seismic ordinance implemented in San Francisco must anticipate the demolition problem:

- The ordinance should prohibit demolition of seismically-substandard housing units unless replacement housing is provided before the demolition occurs.[6]

- Financial assistance must be provided to owners placed in an untenable financial position by upgrading requirements.

- The city must enact strict commercial zoning controls in key neighborhoods in order to limit incentives for demolition and conversion and/or speculation on URM housing sites.

Meshing With Rent Control

The seismic rehabilitation ordinance must be crafted so as to work effectively with the city's rent control ordinance. Three issues must be addressed:

- Relocation: There will be a need for relocation assistance for tenants. The current ordinance, however, does not provide relocation assistance when units must be vacated for rehabilitation. The ordinance should require relocation assistance for involuntary relocation, but should also be crafted to provide incentives for voluntary, temporary relocation during the rehabilitation process.

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[6] We recognize that because of extremely deteriorated conditions, unusual building configuration, or other special circumstances, some buildings may be too costly to save even by minimal upgrading standards. In such cases the City may want to provide special assistance to the building owner in meeting replacement housing requirements.

- Substantial rehabilitation: The rent control ordinance provides that an owner may evict tenants without a right of re-entry when units will be substantially rehabilitated. It is quite possible that thorough seismic upgrading would pass the threshold of "substantial rehabilitation" as defined in the ordinance. Such units are permanently exempt from rent control when they are returned to the market. The city should exclude seismic rehabilitation work as an element in "substantial rehabilitation" to foreclose this possibility.

- Rent pass-through: The rent control ordinance allows an owner to pass through costs for non-cosmetic improvements over a ten-year amortization period. Interest on the expenditures may be imputed and recovered at 10%, unless government loans have been provided at an interest rate of less than 10%. The San Francisco ordinance yields a more favorable response than the Los Angeles ordinance, which allows amortization over only five years. As a result, improvements at the rate of $5000/unit could result in a rent increase of $111/month in Los Angeles, compared with $66/month in San Francisco. The city should seek to minimize rent pass-through by stretching the amortization period for seismic upgrading to 15 years, by lowering the imputed interest rate allowed, and by providing government-backed financing at favorable terms to the maximum extent possible.

Financing Seismic Rehabilitation

The seismic rehabilitation program presents a dilemma; since public funds for housing assistance are limited, application of funds to seismic rehabilitation will detract from funds available for new construction, rent subsidies, or other types of rehabilitation. Choosing among these alternatives obviously raises policy questions for city officials that are outside the scope of our study. If life safety is to be improved in these buildings, however, it is obvious that public assistance will be necessary. Any seismic upgrading ordinance must include a commitment to target substantial public loan and grant monies for that purpose. The following funding sources should be examined:

- Federal grants and loans: Seismic upgrading should be given priority for all federal funds for building rehabilitation. Matching grants of up to $5000/unit are available through the federal rental rehabilitation program if 70% of a building's tenants are low-income. The city's allocation is only about $1 million per year, so these funds are not likely to assist many units unless seismic upgrading is given the highest priority, and a low per-unit allocation is imposed. Non-profit owners of multi-family buildings may also qualify for low interest (6%) loans through the Community Housing Rehabilitation Program, funded by CDBG grants. As much as $1.9 million may be available for all purposes in calendar year 1987. HUD also operates the Section 312 loan program, which provides direct federal loans to owners of predominantly low-income buildings. The city receives no specific allocation, and it is unclear how much assistance will be available through this source in the future.

- State of California programs: The State of California administers at least three loan programs that might be tapped to underwrite seismic upgrading. The Special User Housing Rehabilitation Program provides 30-year loans available only for SRO buildings with 100% low income occupancy; up to $10,000/unit is available under favorable terms. The Deferred Payment Rehabilitation Loan Program provides similar loans on somewhat less favorable terms to non-SRO buildings. The Multi-Family Rehabilitation Program can provide relatively low-cost funds to selected buildings.

- Tax-exempt bonds: The City of San Francisco should join with other affected jurisdictions in an appeal to the state to structure a tax exempt bond issue designed to provide funds for seismic upgrade programs.

- Potential City of San Francisco Programs: At the present time, there is no obvious source of funds for seismic rehabilitation among the city's housing programs. The Housing Affordability Fund, funded through the City's General Fund, may not be continued and would be unlikely to provide significant assistance in any event. Resources of the Office-Affordable Housing Production Program are targeted on producing new units and cannot be used on existing occupied buildings. It would be theoretically possible to use these funds to conserve low income housing in conjunction with a seismic rehabilitation ordinance, but such a decision would require a departure from the focus of the OAHPP to date.

  The city must therefore carefully explore new opportunities to finance seismic upgrading. The following suggestions (by no means an exhaustive list) should be considered: tax exempt bonds, tax-increment financing using the Community Reinvestment Act, exactions through development agreements and other development permissions, and additional, dedicated fees for building permits (a surcharge on permit applications has been proposed in Los Angeles).

- Private loan sources: Particular attention should be given to improving the availability of private loans for seismic rehabilitation work. Private owners of low income rental structures, particularly residential hotels, commonly have great difficulty obtaining private financing for rehabilitation work of any kind. The city might well be able to improve this situation by establishing a loan guarantee program for supervised seismic upgrading, in conjunction with local banks, S&L's and other funding sources. The city should explore the potential for obtaining loans from unconventional sources, e.g., insurance companies with a vested interest in minimizing losses in the event of an damaging earthquake.

MANAGING A RESPONSIBLE UPGRADING PROGRAM

This study underscores the fact that the URM housing stock in San Francisco is a critical resource that is qualitatively different from the URM housing stock in other cities with seismic upgrading ordinances. A large number of units are involved; moreover, those units represent an irreplaceable resource, central to the life of the neighborhoods in which they are concentrated. For those reasons, the city's seismic upgrading ordinance must be implemented very carefully in order to conserve the resource being upgraded, and to minimize the disruptive effects of the upgrading process. Such a program should contain the following elements:

- We recommend that the City develop a 20-year program for implementation of seismic upgrading. A phased program is necessary to make effective use of the region's engineering and construction resources and to minimize "seismic upgrade shock" on tenants and owners.

- The City should take an active role in the upgrading process by obtaining housing for temporary relocation of tenants during the rehabilitation of their buildings. Such temporary relocation will be less disruptive to tenants and less costly to owners, since the rehabilitation work can proceed more quickly without tenants in place. Tenants should also be offered an incentive to find temporary housing on their own.

- Buildings should be cited for upgrading on a block-by-block basis, so that tenants and owners will know when their block will be upgraded, and can make plans accordingly. Furthermore, block-by-block upgrading will achieve net safety gains by ensuring that contiguous buildings are upgraded together. It will also be more convenient for contractors to work on neighboring buildings in a planned manner. For all of these reasons, a block-by-block program is superior to a random citation/upgrading program.[7]

- The City must carefully match the number of buildings cited for upgrade per year to the ability of all parties to engineer, construct, finance and inspect rehabilitation units. An annual work plan will respect the limits of the city's staff, available professionals, and financial resources.

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[7] While the block by block upgrading approach has planning, economic, and structural benefits, the city should take advantage of voluntary upgrading opportunities. If a building owner intended to rehabilitate a building for other reasons, the seismic work should be required, even if that building was scheduled for upgrade requirements at a future date.

To avoid serious disruption of neighborhoods and the housing market, the seismic upgrading ordinance program must proceed in a deliberate, phased manner. The key elements of financing assistance, tenant assistance and ordinance enforcement must be coordinated. It will be necessary to assign responsibility for the seismic program to a central manager with authority to enforce city agency coordination -- which is necessary to contain costs, to pace, finance and rehabilitation, run an efficient citation/permit/ inspection program, and minimize construction time and tenant disruption in each building.

CONCLUSIONS

In summary, we believe a retroactive seismic ordinance in San Francisco is necessary to adequately protect the life-safety of the citizens. However, we feel it would be a mistake to enact a building code ordinance that simply addressed the engineering requirements for improving unreinforced masonry buildings. The data presented here leads us to conclude that a carefully crafted ordinance is necessary to improve the quality of the existing building stock and preserve low-income housing in downtown neighborhoods. Such an ordinance would include:

1. A building code with specific minimum standard and an extended time frame for housing rehabilitation.

2. Demolition controls to protect the housing stock.

3. A revision of the Rent Stabilization Ordinance with special provisions for seismic upgrading to protect tenants from severe rent increases.

4. A program for providing tenants with temporary housing while their buildings undergo seismic retrofit.

5. A financing program to assist building owners in obtaining low-interest loans, tax credits and other financial assistance.

6. A city-sponsored management team to provide coordination between the Bureau of Building Inspection, Planning, Housing and Economic Development, Rent Stabilization, and other city agencies that would be involved in or affected by the program.

This implies that the implementation of such an ordinance must be as carefully designed as the ordinance itself. The materials in this study describe the issues that should be addressed. The challenging work ahead is to create a sensitive ordinance that endorses both seismic safety and housing conservation as policy priorities.

BIBLIOGRAPHY

BUILDING CODES

1979 *California State Historical Building Code*.

1976 City of Long Beach, California. *Earthquake Hazard Regulations for Rehabilitation of Existing Structures within the City*. Subdivision 80 of the Long Beach Municipal Code.

1981 City of Los Angeles, California. *Earthquake Hazard Reduction in Existing Buildings*. Division 88 of Article 1 of Chapter IX of the Los Angeles Municipal Code.

1983 City of Ogden, Utah. Ordinance No. 8-83, Ogden City Municipal Code.

1975 City of Oroville, California. *Resolution of the City of Oroville Establishing Criteria for the Inspection of Buildings Within the City of Oroville.*

1986 City of Palo Alto, California. *Seismic Hazards Identification Program*. Chapter 16.42 of the Palo Alto Municipal Code.

1982 City of San Diego, California. *Amendment to Section 203 of the 1982 UBC.*

1983 City of Santa Ana, California. *Earthquake Hazard Reduction in Existing Buildings*. Article XI of Chapter 8 of the Santa Ana Municipal Code.

1981 City of Santa Monica, California. *Seismic Safety Provisions*. Ordinance No. 1201, amending Section 206 of the 1979 Uniform Administrative Code.

1971 City of Santa Rosa, California. *Resolution No. 9820, A Resolution of the City of Santa Rosa Establishing Criteria for the Inspection of Buildings Within the City of Santa Rosa*.

1979 City of Sebastopol, Califronia. *Existing Buildings: Review and Abatement*. Council Policy 11-A.

1982 City of Seattle, Washington. Section 104: Existing Buildings, Seattle Building Code.

Pate, Marie-Elisabeth.
1979 "Acceptance of a Social Cost for Human Safety: A Normative Approadh." *Proceedings of the 2nd U.S. National Conference on Earthquake Engineering*, Stanford University. Earthquake Engineering Research Institute.

Pate, Marie-Elisabeth.
1979 "Risk and Public Policy." Chapter 2 of "Public Policy in Earthquake Effects Mitigation: Earthquake Engineering and Earthquake Prediction." Technical Report No. 30 of the John A. Blume Earthquake Engineering Center, Stanford University.

Pate-Cornell, Marie-Elisabeth.
1985 "Costs and Benefits of Seismic Upgrading of Some Buildings in the Boston Area." *Earthquake Spectra*, Vol. 1, No. 4, August, 1985.

Petak, William J.
1982 "Development of Earthquake Hazard Reduction Policies in the Cities of Long Beach, Los Angeles, and Santa Ana." Los Angeles, California: National Science Foundation.

Pinkerton, Donald, Executive Director and Cathy Americus, Editor.
1979 *Building Rehabilitation Research and Technology for the 1980's*. National Conference of States on Building Codes and Standards, Inc./National Bureau of Standards. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Planning Advisory Service.
1981 *Reducing Earthquake Risk: A Planner's Guide*. Report No. 364. American Planning Association.

Reed, Richard, ed.
1970 *Living With Seismic Risk, Strategies for Urban Conservation*. Seminar, Casa del Prado, Balboa Park, San Diego. Washington, D.C.: American Association for Advancement of Science.

Rossi, Peter H., James D. Wright and Eleanor Weber-Burdin.
1982 *Natural Hazards and Public Choice: The State and Local Politics of Hazard Mitigation*. San Francisco, California: Academic Press.

Rubin, Claire B.
1985 "Summary of Recent Research on Local Public Policy and Seismic Safety Mitigation." *Societal Implications: Selected Readings*, compiled by Building Seismic Safety Council.

1985 Rehabilitating Hazardous Masonry Buildings: A Draft Model Ordinance. Report SSC 85-06. California Seismic Safety Commission. Sacramento, California.

1986 Uniform Code For Abatement of Hazardous Buildings. Internal Conference of Building Officials.

1985 Uniform Code for Building Conservation. Whittier, California: International Conference of Building Officials.

1979 Uniform Disaster Mitigation Plan. Whittier, California: International Conference of Building Officials.

1975 University Policy-Seismic Safety. University of California.

CONFERENCES AND WORKSHOPS

1982	A Workshop on Continuing Actions to Reduce Losses from Earthquakes in the Mississippi Valley Area. Conference XVIII. St. Louis, Missouri: U.S. Department of the Interior Geological Survey.
1982	A Workshop on Preparing for and Responding to a Damaging Earthquake in the Eastern United States. Conference XV. Reston, Virginia: United States Department of the Interior Geological Survey.
1984	Aspects of Seismic Risk in the New Madrid Fault Region. St. Louis, Missouri: American Society of Civil Engineers, American Institute of Architects, Associated General Contractors.
1985	Designing for Earthquakes in the Pacific Coast States. Seattle, Washington: The American Institute of Architects Foundation and The Seattle Chapter/AIA.
1981	Earthquake and Earthquake Engineering: the Eastern United States. Sponsored by Building Seismic Safety Council, U.S. Department of Energy, Earthquake Engineering Research Institute, and Seismological Society of America. Knoxville, Tennesee. Proceedings published by Ann Arbor Publishers, Inc.
1985	Earthquake Hazard Mitigation Programs at the Community Level. Oakland, California: Bay Area Regional Earthquake Preparedness Project. Materials developed by William Spangle and Associates, Inc. and The Reitherman Company.
1980 1981 1986	First, Second and Third Seminars on Repair and Retrofit of Structures. U.S./Japan Cooperative Earthquake Engineering Research Program. Sponsored by the National Science Foundation. Ann Arbor, Michigan: Department of Civil Engineering, University of Michigan.
1982	FIX'EM: Identification and Correction of Deficiences in Earthquake Resistance of Existing Buildings. Berkeley, California: Earthquake Engineering Research Institute.
1985	How to Reduce Earthquake Damage. Salt Lake City, Utah: American Institute of Architects.
1986	It's Your Fault. San Francisco, California: Bay Area Regional Earthquake Preparedness Project.

1986	Seismic Hazard & Vulnerability. San Francisco, California: Earthquake Engineering Research Institute.
1979	Second U.S. National Conference ofn Earthquake Engineering. Stanford University, Stanford, California: Earthquake Engineering Research Institute.
1980	Seismic Performance of Low Rise Buildings: State-of-the-Art and Research Needs. Sponsored by the National Science Foundation. Proceedings published by the American Society of Civil Engineers.
1986	Structural Design for Earthquakes: an Engineering Short Course. Los Angeles, California: University of Southern California.
1986	The Hazardous Buildings Ordinance: A Key to Earthquake Safety and Economic Recovery. Pasadena, California: Southern California Earthquake Preparedness Project.
1986	Third U.S. National Conference on Earthquake Engineering. Charleston, South Carolina: Earthquake Engineering Research Institute.
1986	UNAM/UCB Collaborative Effort on Earthquake Research. Berkeley, California: Institute of Urban and Regional Development, University of California, and Institute of Social Research, University of Mexico.
1985	U.S.--Japan Workshop on Urban Earthquake Hazards Reduction. Stanford, California: Earthquake Engineering Research Institute.
1985	U.S.A.--Yugoslav Workshop on Protection of Historic Structures and Town Centres in Seismic Regions: Lessons from Montenegro. Petrovac-Budva, Yugoslavia.
1986	US-PRC Joint Workshop on Seismic Resistance of Masonry Structures. Harbin, China.
1981	US/PRC Workshop on Seismic Analysis and Design of Reinforced Concrete Structures. Ann Arbor, Michigan: National Science Foundation.

1985	Workshop on Reducing Seismic Hazards of Existing Buildings. Funded by the Federal Emergency Management Agency. Proceedings published by ABE Joint Venture.
1982	Workshop on the Seismic Upgrading of Existing Buildings: An Interdisciplinary Approach. Sponsored by the National Science Foundation and the Center for Environmental Design Research, College of Environmental Design, University of California, Berkeley.

HOUSING

1986 San Francisco Board of Realtors, *Comparable Book*, Vol. 20 (October 1 - December 31, 1985) and Vol.1 (January 1 - March 31, 1986.)

1986 San Francisco Board of Realtors, *Realtors Multiple Sales Service*. April 21, 1986 and June 30, 1986.

1983 San Francisco Department of City Planning, *North of Market Rezoning Study*.

1985 San Francisco Department of City Planning, *Residential Hotel Unit Conservation and Demolition Ordinance Status Report*.

1986 San Francisco Department of City Planning, "Housing in Chinatown," *Chinatown Planning and Rezoning Study Background Issue Papers*.

1986 San Francisco Department of Public Works, Bureau of Building Inspection Survey of Hazardous Buildings.

1986 San Francisco Department of Public Works, Property Conservation Division Apartment and Hotel Statistics.

1986 "Special Report on Tax Reform." *Housing and Development Reporter*, August 25, 1986.

1986 *The San Francisco Apartment House Directory*, Raybern and Company, Inc., San Leandro, California.

1980 U.S. Bureau of the Census. 1980 Census of Population and Housing. Census Tracts. California.

Paul, Brad, Steve Thompson, Scott Williams and Margeigh Joy.
1985 "The Tenderloin: An Urban Residential Typology." San Francisco, California: North of Market Planning Coalition and Gensler and Assoc. Architects.

Roberts, Benson F. and James Pickman.
1986 *A Community Development Practioner's Guide to the Tax Reform Act of 1986: Low-Income Housing Tax Credits and Other Provisions*, James Pickman & Associates, Inc., Washington, D.C.

Wood, Michael and Rob Waters.
1986 "Tenderloin Rents Soaring, Times Survey Finds," *The Tenderloin Times*, April 1986, p.l.

POLICY

1980 *An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake: Findings and Actions Taken*. Washington, D.C.: Federal Emergency Management Agency.

1985 *City Comprehensive Earthquake Preparedness Planning Guidelines*. Oakland, California: Bay Area Regional Earthquake Preparedness Project.

1985 *Corporate Comprehensive Earthquake Preparedness Planning Guidlines*. Oakland, California: Bay Area Regional Earthquake Preparedness Project.

1985 *County Comprehensive Earthquake Preparedness Planning Guidelines*. Oakland, California: Bay Area Regional Earthquake Preparedness Project.

1976 *Earthquake Prediction and Hazard Mitigation Options for USGS and NSF Programs*. Washington, D.C.: National Science Foundation and Department of the Interior.

1985 *Earthquake Preparedness: A Key to Small Business Survival*. Oakland, California: Bay Area Regional Earthquake Preparedness Project.

1985 "Earthquake Preparedness and Public Information: An Annotated Bibliography." Oakland, California: Bay Area Regional Earthquake Preparedness Project.

1980 *Guideline for Setting and Adopting Standards for Building Rehabilitation*. Washington, D.C.: U.S. Department of Housing and Urban Development Office of Policy Research.

1971 *In the Interest of Earthquake Safety: Findings and Conclusions*. U.S. Task Force on Earthquake Hazard Reduction.

1974 *Meeting the Earthquake Challenge. Final Report to the Legislature of the State of California*. Sacramento: Joint Committee on Seismic Safety.

1976 "NSF Research Applied to National Needs Program. Earthquake Prediction and Hazard Mitigation Options for USGS and NSF programs." National Science Foundation.

1980 *Recommendations for Earthquake hazard reduction programs during fiscal years 80/81 - 85/86.* California Energy Commission.

1984 "Retroactive Earthquake Regulations in Long Beach: An Interview with Edward M. O'Connor." *Building Standards.* Whittier, California: International Conference of Building Officials.

ABE Joint Venture.
1985 *An Action Plan for Reducing Earthquake Hazards of Existing Buildings (FEMA 90).* Washington: Federal Emergency Management Agency.

Alquist, Alfred E.
1972 *Public Hearing on Seismic Hazards of High-rise Buildings in the San Francisco-Bay Area.* California Legislature Joint Committee on Seismic Safety.

Alquist, Alfred E.
1973 *Public Hearing on Seismic Hazards of High-rise Buildings in the Los Angeles Area.* California Legislature Joint Committee on Seismic Safety.

Bay Area Earthquake Study.
1974 *Earthquake Preparedness in the San Francisco Bay Region.* California Seismic Safety Commission and the Federal Emergency Management Agency.

Bay Area Regional Earthquake Preparedness Program.
1986 "The Mexico City Earthquake of Septmeber 19, 1985: Lessons for the Bay Area." *Networks--Earthquake Preparedness News*, February, 1986.

Berg, Glen V.
1982 *Seismic Design Codes and Procedures.* Berkeley, California: Earthquake Engineering Research Institute.

Brown, Rex V.
1985 *Presenting Risk Management Information to Policymakers: Executive Summary.* Technical Report No. 85-4. Falls Church, Virginia: Decision Science Consortium, Inc.

Brown, Robert D. and William J. Kockelman.
1985 "Geology for Decisionmakers: Protecting Life, Property, and Resources." Bulletin of IGS, Vol. 26, No. 1. Berkeley: University of California Institute of Governmental Studies.

Building Seismic Safety Council.
1985 Societal Implications: Selected Readings. Washington, D.C.: Federal Emergency Management Agency.

Burke, Padraic.
1981 "An Economic Perspective on the Effect of Seismic Building Codes on Historic Buildings: A Case Study of Three Buildings in Seattle's Pioneer Square." Proceedings of the Seismic Retrofit of Historic Buildings Conference, April 27, 1981. Sacramento, California.

California Energy Commission.
1980 "Recommendations for Earthquake Harzard Reduction Programs During Fiscal Years 1980/81-85/86." California Seismic Safety Commission.

Chief Administrative Officer, County of Los Angeles.
1973 "Progress Report to the L.A. Co. Board of Supervisors on the Implementation of Recommendations Developed from the Reports of the Earthquake Commission and Earthquake Task Forces: San Fernando, 1971."

City of Los Angeles Building and Safety and Community Development Departments.
1986 "Seismic Safety - Impacts and Issues."

Cochrane, Harold C., J.Eugene Haas, M.J. Bowden, and R.W. Kates.
1974 Social Science Perspectives on the Coming San Francisco Earthquake: Economic Impact, Prediction, and Reconstruction. Boulder: University of Colorado Institute of Behavioral Sciences.

Comerio, Mary C.
1982 "Saving Face, Saving Lives or Saving Neighborhoods: Dealing iwth the Earthquake Problem in the Community," Workshop on the Seismic Upgrading of Existing Building, National Foundation and Center for Environmental Design Research, University of California, Berkeley.

Comerio, Mary C.
1984 "Seismic Sanity: Somebody Else's Problem." *Proceedings of Seminar on Aspects of Seismic Risk in the New Madrid Fault Region*, St. Louis Missouri: American Society of Civil Engineers, American Institute of Architets and Associated General Contractors.

Cooke, Patrick W., ed.
1979 *Regulatory Concerns of Building Rehabilitation*. Washington, D.C.: National Bureau of Standards.

Council of State Governments.
1979 *The States and Natural Hazards*. Lexingtion, Kentucky.

D'Appolonia, E. and D.E. Shaw.
1981 "The Impact of Codes and Regulations in Seismic Safety." *Proceedings of Earthquakes and Earthquake Engineering: the Eastern United States*, Knoxville, Tennessee. Michigan: Ann Arbor Science Publishers, Inc.

De Neufville, Richard.
1975 *How Do We Evaluate and Choose Between Alternative Codes for Design and Performance?* Cambridge: School of Engineering, Massachusetts Institute of Technology. Funded by the National Science Foundation.

Dillon, Robert M.
1985 "Development of Seismic Safety Codes." *Societal Implications: Selected Readings*, compiled by Building Seismic Safety Council. Washington, D.C.: Federal Emergency Management Agency.

Disaster Preparedness Committee.
1979 "Public Official Attitudes Toward Disaster Preparedness in California." Sacramento, California: California Seismic Safety Commission.

Feeley, Frank G. and Blair C. Shick.
1979 "Adaptation of Building Codes to Rehabilitation." *Building Rehabilitation Research and Technology for the 1980's*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

George O. Gates, ed.
1972 *The San Fernando Earthquake of February 9,1971 and Public Policy*. Sacramento, California: Special Subcommittee of the Joint Committee on Seismic Safety.

Gori, Paula L., ed.
1984 *Primer on Improving the State of Earthquake Hazards Mitigation and Preparedness.* Reston, Virginia: U.S. Geological Survey.

Grandori, G. and D. Benedetti
1973 "On the Choice of the Acceptable Seismic Risk." *Earthquake Engineering and Structural Dynamics*, Vol. 2.

Gross, James G.
1985 "Improving Building Regulations for Rehabilitation." *Rehabilitation, Renovation, and Preservation.* Detroit, Michigan: American Concrete Institute.

Hazardous Buildings Committee.
1979 *Hazardous Buildings: Local Programs to Improve Life Safety.* Sacramento: California Seismic Safety Commission.

Hodges, Jane.
1981 *Earthquake Preparedness in California.* Sacramento, California: Joint Committee on Fire, Police, Emergency and Disaster Services.

Holmes, William T. and Howard Thurston.
1985 "Identification of Private Sector On-going Activities." *Proceedings: Workshop on Reducing Hazards of Existing Buildings (FEMA 91).*

International Conference of Building Officials.
1980 *Issues Which Affect the Role of the Building Department in Earthquake Mitigation.* Sacramento: California Seismic Safety Commission.

Kates, Robert W., J. Eugene Haas, Daniel J. Amaral, Robert A. Olson, Reyes Ramos and Richard Olson.
1973 "Human Impact of the Managua Earthquake Disaster." Working Paper No. 23. Boulder, Colorado: Natural Hazard Research.

Konang, Christel.
1982 *Anticipating a Major Earthquake Occurrence: Preliminary Exploration of Nationwide Effects.* Presented at the Atlantic Economic Society Conference, Montego Bay, Jamaica.

Kutner, Scott.
1985 "Los Angeles City Seismic Safety Ordinance: Case Study of Potential Consequences for Central City Residential Hotels." Los Angeles: University of California.

Lew, Franklin.
1982 "A California Building Official's Perspective on Seismic Regulations." *Workshop on the Seismic Upgrading of Existing Buildings*, September 1982, Berkeley. National Science Foundation and Center for Environmental Design Research, University of California, Berkeley.

Lichterman, Joshua David.
1982 *Community Self-Help Disaster Planning and Implementation*. Working Papers in Management Science. Berkeley: Center for Research in Management, University of California.

Mileti, Dennis S., Janice R. Hutton and John H. Sorensen.
1981 *Earthquake Prediction Response and Options for Public Policy*. Boulder: University of Colorado Institute of Behavioral Science.

Monsey, Dr. Arthur.
1984 "Is It Worth It?" *Proceedings of Seminar on Aspects of Seismic Risk in the New Madrid Fault Region*, October 1984. St. Louis, Missouri: American Society of Civil Engineers, American Institute of Architects, and Associated General Contractors.

Moriarty, Paul J.
1979 "Legal Considerations in Building Adoption and Enforcement for Rehabilitation of Existing Buildings." *Building Rehabilitation Research and Technology for the 1980's*, funded by NCSBCS and NBS. Dubuque, Iowa: Kendall/Hunt Publishing Co.

Newman, Paul.
1977 "San Francisco's Parapet Ordinance." San Francisco: Sponsored by The Foundation for San Francisco's Architectural Heritage.

Okrent, David.
1980 "Comment on societal Risk." *Science*, Vol. 208, April, 1980.

Olson, Robert A.
1979 "A Policy Approach to Building Rehabilitation for Earthquake Safety." *Building Rehabilitation Research and Technology for the 1980's*. Dubuque, Iowa: Kendall/Hunt publishing Company.

Panel on the Public Policy Implications of Earthquake Prediction.
1975 *Earthquake Prediction and Public Policy*. Washington, D.C.: National Academy of Sciences.

Pate, Marie-Elisabeth.
1979 "Acceptance of a Social Cost for Human Safety: A Normative Approadh." *Proceedings of the 2nd U.S. National Conference on Earthquake Engineering*, Stanford University. Earthquake Engineering Research Institute.

Pate, Marie-Elisabeth.
1979 "Risk and Public Policy." Chapter 2 of "Public Policy in Earthquake Effects Mitigation: Earthquake Engineering and Earthquake Prediction." Technical Report No. 30 of the John A. Blume Earthquake Engineering Center, Stanford University.

Pate-Cornell, Marie-Elisabeth.
1985 "Costs and Benefits of Seismic Upgrading of Some Buildings in the Boston Area." *Earthquake Spectra*, Vol. 1, No. 4, August, 1985.

Petak, William J.
1982 "Development of Earthquake Hazard Reduction Policies in the Cities of Long Beach, Los Angeles, and Santa Ana." Los Angeles, California: National Science Foundation.

Pinkerton, Donald, Executive Director and Cathy Americus, Editor.
1979 *Building Rehabilitation Research and Technology for the 1980's*. National Conference of States on Building Codes and Standards, Inc./National Bureau of Standards. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Planning Advisory Service.
1981 *Reducing Earthquake Risk: A Planner's Guide*. Report No. 364. American Planning Association.

Reed, Richard, ed.
1970 *Living With Seismic Risk, Strategies for Urban Conservation*. Seminar, Casa del Prado, Balboa Park, San Diego. Washington, D.C.: American Association for Advancement of Science.

Rossi, Peter H., James D. Wright and Eleanor Weber-Burdin.
1982 *Natural Hazards and Public Choice: The State and Local Politics of Hazard Mitigation*. San Francisco, California: Academic Press.

Rubin, Claire B.
1985 "Summary of Recent Research on Local Public Policy and Seismic Safety Mitigation." *Societal Implications: Selected Readings*, compiled by Building Seismic Safety Council.

Schnell, Mary and G. Herd Darrell, ed.
1983 *National Earthquake Hazards Reduction Program: Report to the U.S. Congress, Fiscal Year 1983 Activities*. Alexandria, Virginia: U.S. Geological Survey and Washing ton, D.C.: Federal Emergency Management Agency.

Schulze, William D., David S. Brookshire, John Tschirhart and Ronda Hageman.
1981 "An Economic Analysis of the Benefits and Costs of Seismic Building Codes." *Proceedings of Earthquakes and Earthquake Engineering: The Eastern United States*, Knoxville, Tennessee. Michigan: Ann Arbor Science Publishers, Inc.

Schwartz, Earl.
1979 "Earthquake Rehabilitation of Existing Buildings In the City of Los Angeles." *Building Rehabilitation Research and Technology for the 1980's*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Scott, Stanley.
1979 *What Decisionmakers Need to Know: Policy and Social Science Research on Seismic Safety*. Research Report 79-5. Berkeley: University of California Institute of Governmental Studies.

Scott, Stanley.
1968 "Preparing for Future Earthquakes: Unfinished Business in the San Francisco Bay Area." Bulletin of IGS, Vol. 9, No. 6. Berkeley: University of California Institute of Governmental Studies.

Scott, Stanley.
1976 "Learning to Live with Earthquakes: Research and Policy for Seismic Safety in California." Bulletin of IGS, Vol. 17, No. 5. Berkeley: University of California Institute of Governmental Studies.

Simpson-Housely, Paul.
1979 "Locus of Control, Repression-Sensitization and Perception of Earthquake Hazard." Working Paper #36. Boulder, Colorado: Natural Hazard Research.

Scott, Stanley.
1979 *Policies for Seismic Safety: Elements of a State Government Program*. Berkeley: University of California Institute of Governmental Studies.

Spangle, William and Associates, Inc.
1986 "Pre-Earthquake Planning for Post-Earthquake Rebuilding." Funded by the National Science Foundation.

Starr, Chauncey.
1969 "Social Benefit versus Technological Risk--What is our society willing to pay for safety?" *Science*, Vol. 165, September 19, 1969.

Steinbrugge, Karl V.
1968 *Earthquake Hazard in the San Francisco Bay Area: A Continuing Problem in Public Policy*. Berkeley: University of California Institute of Governmental Studies.

Steinbrugge, Karl V. and Carl B. Johnson.
1973 "Earthquake Hazard and Public Policy in California." *Engineering Issues*, Vol. 99, No. PP4, October 1973. American Society of Civil Engineers.

Steinbrugge, Karl V. and Henry J. Degenkolb.
1975 "Meeting the Earthquake Challenge: California's New Laws." *Civil Engineering*. American Society of Civil Engineers.

Tate, Barry.
1979 "Financial Feasibility of Rehabilitation." *Building Rehabilitation Research and Technology for the 1980's*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Taylor, Nathanial.
1979 "City Planning and Rehabilitation: San Francisco." *Building Rehabilitation Research and Technology for the 1980's*. Dubuque, Iowa: Kendall/Hunt Publishing Company.

Ward, Delbert B.
1984 "Management of Earthquake Safety Programs by State and Local Governments." *Societal Implications: Selected Readings*, compiled by Building Seismic Safety Council.

Wiggins, John H. Jr.
1972 "The Balanced Risk Concept: New Approach to Earthquake Building Codes." *Civil Engineering*, August 1972. American Society of Civil Engineers.

Working Group on Earthquake Hazards Reduction.
1978 *Earthquake Hazards Reduction: Issues for an Implementation Plan*. Office of Science and Technology Policy, Executive Office of the President.

Wyner, Alan J. and Dean E. Mann.
1986 *Preparing for California's Earthquakes: Local Government and Seismic Safety*. Berkeley: University of California, Institute of Governmental Studies.

Zsutty, Theodore C. and Haresh C. Shah.
1985 "The Purpose and Effects of Earthquake Codes." *Societal Implications: Selected Readings*, compiled by Building Seismic Safety Council. Washington, D.C.: Federal Emergency Management Agency.

TECHNICAL

1977
1978 "Designing for Earthquakes: Summer Seismic Institutes for Architectural Faculty." Stanford University: AIA Research Corporation.

1971 *Earthquake Risk: Proceedings of a Conference Held in 9/71*. Joint Committee on the San Fernando Earthquake Study.

1977 Learning from Earthquakes: *1977 Planning and Field Guide*. Earthquake Engineering Research Institute, with support from the National Science Foundation.

1985 *Recommended Lateral Force Requirements and Commentary*. Structural Engineers Association of California.

1976 "Report of Task Committee of the Seismic Safety Commission on Seismic Hazard from State-Owned Buildings."

1985 "Seismic bracing idea gives design flexibility." *Engineering News Record*, July 11, 1985. McGraw-Hill, Inc.

1986 "The Mexico City Earthquake of September 19, 1985: Lessons for the Bay Area." Oalkand, California: Bay Area Regional Earthquake Preparedness Project.

Agbabian, M.S.
1981 "Seismic Resistance of Interior Partitions." *Proceedings of the Second Seminar on Repair and Retrofit of Structures*. Ann Arbor, Michigan: Department of Civil Engineering, University of Michigan.

Ambrose, James.
1980 *Simplified Building Design for Wind and Earthquake Forces*. John Wiley and Sons.

Anand, Subhash C., ed.
1985 *New Analysis Techniques for Structural Masonry*. Proceedings of a session held in conjunction with Structures Congress '85, Chicago, 9/18/85. New York: American Society of Civil Engineers.

Anderson, R.W., Principal Investigatior for Agbabian Associates.
1981 *Investigation of the Seismic Resistance of Interior Building Partitions*. El Segundo, California: National Science Foundation.

Applied Technology Council.
1984 *Tentative Provisions for the Development of Seismic Regulations for Buildings, ATC 3-06*. Palo Alto, California: National Science Foundation and National Bureau of Standards.

Arnold, Christopher.
1982 "The Building on Your Board Won't Hurt You." *FIX'EM: Identification and Correction of Deficiencies in Earthquake Resistance of Existing Buildings*. Berkeley, California: Earthquake Engineering Research Institute.

Arnold, Christopher and Robert Reitherman.
1981 *Building Configuration and Seismic Design*. National Science Foundation.

Arnold, Christopher.
1984 "Primacy, Decline, and Decrepitude: The Building Life Cycle, and Its Relationship to Earthquake Hazard Reduction Strategies." *Primer on Improving the State of Earthquake Hazards Mitigation and Preparedness*. Reston, Virginia: U.S. Geological Survey.

Association of Bay Area Governments.
1982 *Building Stock and Earthquake Losses--The San Francisco Bay Area Example*. Funded by the National Science Foundation.

Building Seismic Safety Council and National Bureau of Standards.
1982 *Plan for a Trial Design Program to Assess Ammended ATC 3-06*. Washington,D.C.

Building Seismic Safety Council and National Bureau of Standards.
1982 *Amendments to ATC 3-06*. Washington, D.C..

Building Seismic Safety Council.
1986 *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*. Washington, D.C.: Federal Emergency Management Agency.

Building Seismic Safety Council.
1986 *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*. Earthquake Hazards Reduction Serties 17. BSSC Program on Improved Seismic Safety Provisions. Sponsored by the Federal Emergency Management Agency.

Bolt, Bruce A. and Richard H. Jahns.
1979 "California's Earthquake Hazard: A Reassessment." *Public Affairs Report*, Vol.20, No.4. Berkeley: University of California Institute of Governmental Studies.

Bouhafs, Mourad.
1985 *Evaluation of the Seismic Performance of Existing Buildings*. Thesis, Master of Architecture, University of California, Berkeley.

Bresler, Boris.
1981 "Multi-Hazard Evaluation of Existing Buildings." *Proceedings: US/PRC Workshop on Seismic Analysis and Design of Reinforced Concrete Structures*. Ann Arbor, Michigan: National Science Foundation.

Britz, Kenneth I., Lizabeth Libby and Dewi Hadinata.
1981 *The Integration of Seismic Design Principles Into Preliminary Architectural Design*. Institute of Building Sciences, Carnegie-Mellon University.

Comerio, Mary and Hal Levin, Project Directors.
1982 *Earthquake Hazards and Wood Frame Houses: What You Should Know and Can Do*. Berkeley: Center for Planning and Development Research, College of Environmental Design, University of California.

Comerio, Mary and Sanford Hirshen, Principal Investigators.
1982 *An Earthquake Advisor's Handbook for Wood Frame Houses*. Berkeley: Center for Planning and Development Research, College of Environmental Design, University of California.

Committee on Hazardous Buildings of the Seismic Safety Commission.
1985 *Earthquake Safety: Potentially Hazardous Buildings*. Report No. SSC 85-04 Sacramento: State of California Seismic Safety Commission.

Committee on the Alaska Earthquake.
1969 *Toward Reduction of Losses from Earthquakes: Conclusions from the Great Alaska Earthquake of 1964*. Washington, D.C.: National Academy of Sciences.

Consejo Nacional de Ciencia y Tecnologia and Committee on Earthquake Engineering.
1986 "Research Agenda: Learning from the 19 September 1985 Mexico Earthquake." National Research Council.

Cresswell, M.M., compiler.
1981 *Large Earthquakes in New Zealand*. The Royal Society of New Zealand.

Culver, Charles G., H.S. Lew, Gary C. Hart and Clarkson W. Pinkham.
1975 Natural Hazards Evaluation of Existing Buildings. Building Science Series 61. U.S. Department of Commerce/National Bureau of Standards.

Degenkolb, H.J. Associates, Engineers.
1983 Report on Observations: Earthquake of May 2, 1983, Coalinga, California.

Demoro, Harre.
1986 "Earthquake...City is in Flames." San Francisco Chronicle, April 18, 1986.

Di Iorio, Cristine.
1984 Seismic Retrofit of Historic Unreinforced Masonry Buildings: Economic, Structural and Architectural Issues. Riverside: University of California Graduate School of History.

Earthquake Engineering Systems, Inc.
1978 A Rational Approach to Damage Mitigation in Existing Structures Exposed to Earthquakes. San Francisco, California: National Science Foundation.

Ellingwood, A.M.
1981 "Analysis of Reliability for Masonry Structures." Journal of the Structural Division, Vol.107, No.ST5, May 1981. American Society of Civil Engineers.

Elsesser, Eric.
1985 "Structural concepts for a Seismic Protection of Historic Buildings." Presented at the U.S.A.--Yugoslave Wrokshop on Protection of Historic Structures and Town Centres in Seismic Regions: Lessions From Montenegro. Petrovac-Budva, Yugoslavia.

Ferritto, John M.
1981 "Economic Review of Earthquake Design Levels." Journal of the Structural Division, August 1981. American Society of Civil Engineers.

Fuller, G. Robert.
1980 "Seismic Evaluation and Rehabilitation of HUD Residential Buildings." Proceedings of the First Seminar on Repair and Retrofit of Structures. Ann Arbor, Michigan: Department of Civil Engineering, University of Michigan.

Gauchat, Urs P., Daniel L. Schodek and Rene Luft.
1984 Patterns of Housing Type and Density: A Basis for Analyzing Earthquake Resistance. Cambridge: Department of Architecture, Graduate School of Design, Harvard University. Funded by The National Science Foundation.

Harris, James Robert.
1984 "The BSSC Trial Design Program." Proceedings of Seminar on Aspects of Seismic Risk in the New Madrid Fault Region, October 1984. St. Louis, Missouri: American Society of Civil Engineers, American Institute of Architects, and Associated General Contractors.

Johnson, Albin W.
1981 "Some Detail Considerations for Anchorage in Unreinforced Masonry Buildings." Proceedings: US/PRC Workshop on Seismic Analysis and Design of Reinforced Concrete Structures. Ann Arbor, Michigan: Department of Civil Engineering, University of Michigan. Funded by the National Science Foundation.

Kahn, Lawrence F.
1981 "Repair and Strengthening of Masonry." Proceedings: US/PRC Workshop on Seismic Analysis and Design of Reinforced Concrete Structures. Ann Arbor, Michigan: Department of Civil Engineering, University of Michigan. Funded by the National Science Foundation.

Kahn, Lawrence F.
1984 "Seismic Retrofit." Primer on Improving the State of Earthquake Hazards Mitigation and Preparedness. Reston, Virginia: U.S. Geological Survey.

Kariotis, J.C., R.D. Ewing, and A.W. Johnson.
1986 "Methodology for Mitigation of Earthquake Hazards in Unreinforced Brick Masonry Buildings." Proceedings of US-PRC Joint Workshop on Seismic Resistance of Masonry Structures. Harbin, China.

Kariotis, J.C., R.D. Ewing, and A.W. Johnson.
1986 "Predictions of Stability for Unreinforced Brick Masonry Walls Shaken by Earthquakes." Proceedings of US-PRC Joint Workshop on Seismic Resistance of Masonry Structures. Harbin, China.

Kariotis, Kesler, and Allys.
1978 *Mitigation of Seismic Hazards in Existing Unreinforced Masonry Wall Buildings: Performance of Undesigned and Modified Elements. Evaluation of Modification Methods*. South Pasadena, California: National Science Foundation.

Kunreuther, Howard, John Lepore, Louis Miller, Joseph Vinso, John Wilson, Bradley Borkan, et.al.
1978 *An Interactive Modeling System for Disaster Policy Analysis*. Monograph #26. University of Colorado: Institute of Behavioral Science, Program on Technology, Environment and Man.

Kutsu, Onder.
1979 "A Practical Approach to Damage Mitigation in Existing Structures Exposed to Earthquakes." *Proceedings of the 2nd U.S. National Conference on Earthquake Engineering*, Stanford University. Earthquake Engineering Research Institute.

Lagorio, Henry J., Howard Friedman, and Kit Wong.
1986 *Issues for the Seismic Strengthening of Existing Buildings: A Practical Guide for Architects*. Berkeley: Center for Environmental Design Research, University of California.

Leslie, Stephen K. and J.M. Biggs.
1972 *Earthquake Code Evolution and the Effect of Seismic Design on the Cost of Buildings*. Cambridge: School of Engineering, Massachusetts Instute of Technology, funded by the National Science Foundation.

Lomnitz, C. and E. Rosenblueth, eds.
1976 *Seismic Risk and Engineering Decisions*. New York: Elsevier Scientific Publishing Company.

Los Angeles County Earthquake Commission.
1971 "San Fernando Earthquake, February 9, 1971."

Loss, John.
1981 *Building Design for Natural Hazards in the Eastern United States*. National Science Foundation.

Mann, O. Clarke.
1984 "Seismically Safe Structures and Their Cost-Effectiveness." *Primer on Improving the State of Earthquake Hazards Mitigation and Preparedness*. Reston, Virginia: U.S. Geological Survey.

Martini, Kirk.
1982 *Unreinforced Masonry Buildings: Seismic Behavior and Renovation*. Berkeley, California: Center for Environmental Design Research, University of California.

Miller, Richard K. and Stephen F. Felszeghy.
1978 *Engineering Features of the Santa Barbara Earthquake of August 13, 1978*. Berkeley: Earthquake Engineering Research Institute.

National Earthquake Hazards Reduction Program Participants.
1981 *Summaries of Technical Reports*, Volume XIII. Menlo Park, California: U.S. Geological Society.

Oppenheim, I.J.
1979 "Economic Analysis of Earthquake Engineering Investment." *Proceedings of the 2nd U.S. National Conference on Earthquake Engineering*, August 22-24, 1979. Earthquake Engineering Research Institute.

Page, Robert A., John A. Blume and William B. Joyner.
1975 "Earthquake Shaking and Damage to Buildings." *Science*, Vol. 189, No. 4203, August 22, 1975.

Platt, Christine M. and Robin Shepherd.
1985 "Some Cost Considerations of the Seismic Strengthening of Pre-Code Buildings." *Earthquake Spectra*, Vol. 1, No. 4, August 1985. Berkeley, California: Earthquake Engineering Research Institute.

Reitherman, Robert.
1984 "Seismic Damage to Unreinforced Masonry Buildings." *Case Studies of the Earthquake Performance of Unreinforced Masonry Buildings*. Funded by the National Science Foundation. Redwood City, California: Scientific Service, Inc.

Reitherman, Robert.
1985 *Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide*. Oakland, California: Bay Area Regional Earthquake Preparedness Project.

Sabnis, Gajanan, ed.
1985 *Rehabilitation, Renovation, and Preservation*. Detroit, Michigan: American Concrete Institute.

Steinbrugge, Karl V.
1982 *Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards*. New York: Skandia America Group.

Steinbrugge, Karl V. and Henry J. Lagorio.
1985 "Relative Earthquake Safety in Buildings." *California Geology*. State of California Department of Conservation, Mines and Geology.

Structural Engineers Association of California.
1985 *Earthquake Hazard Mitigation of Unreinforced Masonry Buildings built prior to 1934*.

URS/John A. Blume & Associates, Engineers.
1974 *San Francisco Seismic Safety Investigation*. Prepared for the Department of City Planning, City of San Francisco.

Vanmarcke, Erik H.
1976 "Structural Response to Earthquakes." *Seismic Risk and Engineering Decisions*, Chapter 8. New York: Elsevier Scientific Publishing Company.

Whitman, Robert V.
1973 "Damage Probability Matrices for Prototype Buildings." Cambridge: Department of Civil Engineering, Massachusetts Institute of Technology.

Whitman, Robert V., Frank J. Heger, Rene W. Luft and Frederick Krimgold.
1980 "Seismic Resistance of Existing Buildings." *Journal of the Structural Division*, July 1980. American Society of Civil Engineers.

Whitman, Robert V., John Biggs, John Brennan, C.Allin Cornell, and Richard de Neufville.
1975 "Seismic Design Decision Analysis." *Journal of the Structural Division*, May 1975. American Society of Civil Engineers.

Yanev, Peter.
1980 *Peace of Mind in Earthquake Country*. San Francisco, California: Chronicle Books.